APPENDIX E

Simulation of Operational Alternatives For The Lake Okeechobee Regulation Schedule Study

Hydrologic Evaluation Final Report
Jacksonville Corps of Engineers
Water Resources Branch, Hydrologic Modeling Section

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INTRODUCTION

Purpose and Scope of this Report

In support of the Lake Okeechobee Regulation Schedule Study (LORSS), the system-wide effectiveness of several alternative water regulation schedules were simulated with the South Florida Water Management Model (SFWMM). The major assumptions and results of this effort are presented in this report to provide other study team members with information for further analysis. Also included in this report is a precursory evaluation of the trade-offs between the competing objectives for managing Lake Okeechobee.

The synthesis of the findings of these multiple analyses will be prepared by the U.S. Army Corps of Engineers (Corps). This report is intended to help document the characteristics of each alternative and provide a cursory review of the performance associated with each alternative.

Background

Lake Okeechobee is the second largest freshwater lake lying wholly within the boundaries of the United States. Lake Okeechobee benefits south Florida by storing enormous volumes of water during wet periods for subsequent environmental, urban and agricultural needs during dry periods. However, extended periods of high water levels within Lake Okeechobee have been identified as causing stress to the integrity of the Herbert Hoover Dike as well as Lake Okeechobee's littoral zone. To accommodate south Florida's potential for heavy rains and severe tropical storms, a lower lake regulation schedule is needed until levee remdiation can be completed. This accommodation requires that water levels in the lake do not rise to levels that would threaten the structural integrity of the levee system surrounding Lake Okeechobee. Therefore, when water levels in the lake reach certain elevations designated by the regulation schedule, discharges are made through the major outlets to control excessive buildup of water in Lake Okeechobee. The timing and magnitude of these releases is not only important for preserving the flood protection of the region, but also for protecting the natural habitats of downstream estuaries and the Everglades.

The multiple objectives associated with managing the lake water levels are:

- Ensure public health and safety.
- Manage Lake Okeechobee at optimal lake levels to allow recovery of the lake's environment and natural resources.
- Reduce high regulatory releases to the Caloosahatchee and St. Lucie estuaries so that the health of the estuaries are not compromised.
- Continue to meet congressionally authorized project purposes including: flood control, water supply, navigation and recreation, as well as fish and wildlife enchancement.

OVERVIEW OF THE SCHEDULES EVALUATED

This report presents the hydrologic simulation results and an evaluation of the hydrologic performance of the final array of regulation schedule alternatives designed to lower the normal operating limits of Lake Okeechobee while meeting the above objectives. The final seven alternative schedules, plus the No Action Alternative, include:

- The No Action Alternative: current regulation schedule, Water Supply and Environment (WSE), with the addition of temporary forward pumps;
- The LORS-FWO Alternative which is similar to the No Action Alternative with a general lowering of the top two regulatory relaase lines and the addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Alternative 1bS2-A17.25 which is a similar approach to WSE with a general lowering of the top three regulatory release lines, reduced magnitude of maximum discharge decisions in Zone B and Zone C to the St. Lucie Estuary, a reshaping of the line representing the divide between Zone D and Zone E, redefinition of some of the WSE meteorological inputs, and the addition of a new regulatory base flow zone for the Calosahatchee Estuary;
- Alternative 1bS2-m which is similar to Alternative 1bS2-A17.25 but with a lowering of the second and third regulatory release lines and a lowering of the top three regulatory release lines during the late hurricane season from September 15 through November 1;
- Alternative 2a-B which represents a new appoach to defining the regulatory release bands (based on a defined target operational guideline), and includes removal of the seasonal and multi-seasonal forecasting indices utilized under the WSE decision tree framework, and the addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Alternative 2a-m which represents a more aggressive approach to Alternative 2a-B in passing low-level, non-damaging releases to the estuaries to further reduce the normal lake levels, and includes increased magnitude releases to tide in advance of reaching the highest release band;
- Alternative 3-B which represents an approach similar to Run22AZE, from the last regulation schedule study, but with a lowering of the upper two regulatory lines and addition of a new regulatory base flow zone for the Caloosahatchee Estuary;
- Alternative 4-A17.25, a more agressive modification–but similar to–Alternative 1bS2-A17.25, which includes higher maximum release magnitudes to tide for Zone B and Zone C, increased maximum release magnitudes to tide under dry seasonal forecast in Zone C and Zone D, and lowering of the top three regulatory release lines during the late hurricane season.

With the expception of the No Action Alternative, the final set of alternatives, above, were developed to achieve a few common goals: to achieve zero or close-to-zero days above lake elevation of 17.25 feet National Geodetic Vertical Datum of 1929 (NGVD); to provide a base flow to one or both of the estuaries in order to minimize the occurrence of high, damaging release to the estuaries; to include a maximum limit of the lake regulatory releases passed through STA3/4, based on assumed treatment capacity given the current nutrient levels within Lake Okeechobee; and to provide lake operators with as much flexibility as possible to lower the lake stages when needed to achieve the project objectives. All alternatives, except Alternative

2a-B and Alternative 2a-m, included similar use of the WSE meteorological guidelines and decision tree framework; all alternatives included use of a the Tributary Hydrological Conditions (THC) indicators concept, as found in WSE but modified to utilize the Palmer Index (in the place of net basin rainfall) and Lake Okeechobee net inflows (in the place of inflows at S-65E). The South Florida Water Management District (SFWMD) Supply Side Management (SSM) Line is assumed to be lowered by 1.0 feet from the current SSM line under all alternatives. The assumption of a lowered SSM line serves as a surrogate for the SSM update effort anticipated to be completed by the SFWMD prior to implementation of a new lake regulation schedule (to be identified by this LORS study), but the assumption is unable to be included as part of the No Action Alternative; the assumption of a 1.0-foot lowering of the SSM line for all alternatives is based on a recommendation from the SFWMD technical staff working on the parallel effort to update the SSM rules. Completion of the SFWMD SSM update effort requires identification of the Tentatively Selected Plan (TSP) by the Corps.

The schedules which included the WSE decision tree framework were designed to increase operational flexibility. Considering the dynamic shifting of priorities for managing Lake Okeechobee, it appears desirable to design flexible operating rules that give water managers some latitude to utilize best available multi-disciplinary information, and adjust operations as necessary to achieve a better balance of the competing objectives. Considering the potential benefits from recent lake inflow forecasting tools, and the rapid increase in the state-of-the-art in forecasting technology, it is practical to establish more flexible rules which allow lake managers to utilize supplemental information and apply their sound judgement in making operational decisions. A detailed discussion of WSE will not be provided in this report; however, differences from WSE will be discussed, below, as part of the individual alternatives.

LORS-FWO Alternative

The No Action Alternative, which includes the current WSE regulation schedule for Lake Okeechobee and assumes SFWMD temporary forward pumps in place, calls for maximum practicable releases from Lake Okeechobee when lake stages are within Zone A–a range from elevation 17.00 ft on May 31 to elevation 18.50 ft from October through March. The No Action Alternative does not include a zone for base flow releases to either the Caloosahatchee or St. Lucie Estuaries. In order to properly evaluate the potential effects of allowing for maximum releases above 17.25 elavation and base flow to the estuaries, in the absence of additional changes to the WSE regulation schedule, alternative LORS-FWO (future with operations modified) was developed with the following changes to the No Action Alternative:

1. Zones A and B are lowered where necessary to allow maximum practicable releases under all conditions when the Lake Okeechobe stage exceeds 17.25 ft, NGVD. The regulation schedule is shown in Figure 1.

2. An additional regulatory zone is added (below Zone D) to allow for base flow releases to the Calosahatchee Estuary. During the alternative formulation process, data and recommendations were evaluated and the recommended base flow release was determined to be 450 cfs to the Caloosahatchee Estuary (measured at S-79) and zero base flow to the St. Lucie Estuary.

Alternative 1bS2-A17.25

Alternative 1bS2-A17.25 was developed from the current WSE decision tree structure. The regulation schedule and decision trees for Lake Okeechobee discharges to the Water Conservation Area (WCAs) and discharges to tidewater for Alternative 1bS2-A17.25 are shown in Figure 2, Figure 3, and Figure 4, respectively. Operational experience under WSE and the availability of additional climatological data led to the following recommended modifications to WSE for this alternative:

1. Regulation schedule lines for Zone A, Zone B, and Zone C are lowered. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater. The lowering of the upper regulatory zones results in a regulation schedule that is more pro-active to limit potential high water conditions within Lake Okeechobee.

2. THC are applied that represent longer term wet or dry conditions that have persisted in the tributaries. Updated THC indicators enable the proposed regulation schedule to avoid frequent breaks in the regulatory outflows that may occur due to shorter dry periods. The Palmer Index is proposed to replace the 30-day net rainfall, and the 14-day mean Lake Okeechobee net inflow (LONIN) is proposed to replace the 14-day mean S-65E flow. The classification bands for the PDSI and LONIN THC indicators are summarized in Table 1.

3. The line representing the divide between Zone D and Zone E is reshaped: the bottom of Zone D is flattened during the periods in which the estuary ecological systems may be more impacted by large freshwater discharges, especially in late winter, early spring, and during the October through November period. The modified regulatory line promotes a quicker response in the autumn and winter months to large inflows that often are generated during the hurricane season.

TABLE 1: DEFINITION OF TRIBUTARY CONDITIONS BASED ON THE PALMER INDEX AND NET INFLOW

Tributary Hydrologic Classification	Palmer Index Class Limits	2-wk mean L.O. Net Inflow Class Limits
Very Wet	3.0 or greater	Greater >= 6000 cfs
Wet	1.5 to 2.99	2500-5999 cfs
Near Normal	-1.49 to 1.49	500-2499 cfs
Dry	-1.5 to -2.99	-5000 – 500 cfs
Very Dry	-3.0 or less	Less than -5000 cfs

4. A new base flow zone (Zone D0) is established below the bottom of the re-shaped Zone D. Base flow is allowed when Lake Okeechobee water levels are in Zone D0 or above (Zone C decision tree outcome for dry THC, seasonal, and multi-seasonal forecasts is base flow), but no base flow releases are called for when the stage falls below the bottom of Zone D (Zone D0). During the alternative formulation process, data and recommendations were evaluated and the recommended base flow release was determined to be 450 cfs to the Caloosahatchee Estuary (measured at S-79) and zero base flow to the St. Lucie Estuary. Risks to the water supply performance objective are anticipated to be minimized with the forward pumps assumed in place to allow for water supply at lower lake water levels. The bottom of the base flow zone ranges from 11.5 ft, NGVD on May 31 to 13.0 feet during October and November. For Figure 3 (discharges to WCAs), releases to the WCAs when in Zone D0 adhere to the same decision tree as the remainder of Zone D; for Figure 4 (discharges to tidewater), releases when in Zone D0 will be base flow, and the decision tree of Zone D is not applicable.

5. THC and seasonal climate forecasts are updated to allow increased operational flexibility in managing lake stages, and specifically to avoid extreme high lake stages. A significant number of decision tree outcomes for THC and seasonal forecast are updated to allow the quicker release of lake water, as compared to WSE (for example, “Extremely wet” THC is changed to “very wet” or “wet to very wet” is changed to “normal to wet”). The additional inclusion of lake stages forecasted to rise into Zones A or B also introduces additional operator flexibility by allowing for utilization of all available hydrologic and meteorological forecasting data. The changes to WSE for Alternative 1bS2-A17.25 are indicated by the red font in Figure 4.

6. Moderate to extreme high discharges to the St. Lucie Estuary are reduced by modifying the maximum discharge rates for Zone B and Zone C from 3500 to 2800 cfs and 2500 to 1800 cfs, respectively.

<u>Alternative 1bS2-m</u>

Alternative 1bS2-A17.25 simulation output (SFWMM model) showed the 17.25 feet stage criteria for Lake Okeechobee extreme high water to be exceeded for 12 days during the 36-year simulation period-of-record. Alternative 1bS2-A17.25 was modified to remove any simulated daily stage in excess of 17.25 feet within Lake Okeechobee. The modifications to Alternative 1bS2-A17.25 to create Alternative 1bS2-m are summarized below:

1. Regulation Zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1)

2. Regulation lines for the bottom of Zones B and C were lowered. Zone B breakpoints were first lowered to be mid-way between the bottom of Zone A and the bottom of Zone C. The bottom of Zone B was then lowered by an additional 0.15 ft and the bottom of Zone C was lowered by 0.10 feet, as required to achieve zero days with lake stage greater than 17.25 ft elevation. The simulated peak stage for Lake Okeechobee is 17.23 ft, during October 1995.

The regulation schedule for Alternative 1bS2-m is shown in Figure 5; the decision tree remains unchanged from Alternative 1bS2-A17.25 (Figure 3 and Figure 4).

Alternative 2a-B

Alternative 2a-B represents a new appoach to defining the regulatory release bands, based on a defined target operational guideline. The regulation schedule and decision trees for Lake Okeechobee discharges to the WCAs and discharges to tidewater for Alternative 2a-B are shown in Figure 6, Figure 7, and Figure 8, respectively. The operational details of Alternative 2a-B are summarized below:

1. The operational guideline was developed by the Corps Water Management Section based on evaluation of historical stages of Lake Okeechobee from 1965 through 2005. As the lake stages increase further above the operational guideline, regulatory releases increase according to the specified regulatory bands;

2. The upper two regulatory lines were defined based on the probability (50% and 25%) of Lake Okeechobee stages reaching 17.50 feet within the next 90 days, assuming discharge outlets to tidewater were significantly limited. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25);

3. Below the operational guideline, base flow to the Caloosahatchee Estuary of 450 cfs is permitted but discontinued if the lake falls below the assumed 12.56 ft elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current SSM line, whichever is higher;

4. The decision tree for Alternative 2a-B includes removal of the seasonal and multi-seasonal forecasting indices utilized under the WSE decision tree framework, utilizing only the THC indicators of the PDSI and LONIN, as used in all alternatives;

5. Regulatory releases fom Lake Okeechobee to the WCAs are discontinued when the lake stage falls below 13.50 ft, NGVD.

Alternative 2a-m

Alternative 2a-B was modified to significantly reduce the frequency of extreme high discharge to the Caloosahatchee and St. Lucie Estuaries, with the resulting alternative being Alternative 2a-m. The modifications to Alternative 2a-B are summarized below, and the regulation schedule is shown in Figure 9. The decision tree for Alternative 2a-m is unchanged from the decision tree utilized for Alternative 2a-B (Figure 7 and Figure 8).

1. Releases to tidewater for the regulatory band between the 25 percent and 50 percent high water probability lines (Blue band) are increased from 6500 cfs to Caloosahatchee/3500 cfs to St. Lucie to 7500 cfs/5000 cfs, with the intention to reduce the duration of extreme high estuarine discharges but also recognizing the possibility that these higher release

volumes may cause additional impacts to public health and safety downstream of the St. Lucie lock.

2. Releases to tidewater for the regulatory band between the operational guideline and 13.50 feet elevation (magenta band) is modified from a regulatory band for Caloosahatchee Estuary baseflow to a low level regulatory release of 800 cfs to the Caloosahatchee Estuary and 400 cfs to the St. Lucie Estuary. The magenta regulatory band was also extended to include the area between 13.50 elevation and the operatinal guideline minimum elevation of 12.50 feet, which was not included for Alternative 2a-B;

3. The bottom of the base flow regulatory band (bottom the orange band / top of red band) was modified to be consistent with Alternative 1bS2-A17.25 and Alternative 1bS2-m, with a minimum elevation of 11.50 ft and a maximum elevation of 13.0 ft.

<u>Alternative 3-B</u>

The conceptualization for Alternative 3 was developed from Run22AZE. The operational schedule Run22AZE was evaluated under the previous LORSS (2000) that resulted in the selection of WSE, at which time Run22AZE was recommended as the most desirable schedule for the Lake Okeechobee littoral zone system. The regulation schedule for Run22AZE is shown in Figure 10. The regulation schedule for Run22AZE was modified for this regulation schedule study with the following changes, as shown in Figure 11:

1. The upper two regulatory lines are lowered. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25). The Run22AZE operational schedule included maximum practicable releases when stages exceeded 18.50 ft for October through February.

2. A new regulatory base flow zone for base flow to the Caloosahatchee Estuary is defined below the bottom regulatory line of the Run22AZE operational schedule. Base flow releases for the Calooschatchee Estuary are discontinued if the lake falls below the assumed 12.56 ft elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current SSM line, whichever is higher.

The operational criteria for releases to the WCAs and releases to the estuaries remain unchanged from the zones defined for Run22AZE; Zone A and Zone B breakpoints have, however, been modified as noted in item 1 above.

Alternative 4-A17.25

Alternative 4 was developed similarly to Alternative 1bS2-A17.25. Alternative 4, however, was intended to provide additional operational flexibility to manage the lake stages at lower levels than Alternative 1bS2-A17.25. The regulation schedule for Alternative 4 is shown in Figure 12. Alternative 4 includes all of the modifications to the No Action Alternative that were included in Alternative 1bS2-A17.25, with the following additional modifications:

1. Maximum releases in Zone B and Zone C for normal to wet THC are unchanged from the No Action Alternative: 6500 to Caloosahatchee Estuary/3500 to St. Lucie Estuary in Zone B and 4500/2500 in Zone C. If the stage of Lake Okeechobee exceeds 17.25 ft, NGVD, the regulation schedule decision tree specifies maximum practicable releases to the WCAs and tidewater (same as Alternative 1bS2-A17.25);

2. Regulation Zones A, B, and C are lowered during the late hurricane season (September 30 stage breakpoints are changed to November 1);

3. Zone D decision tree outcome for THC "normal" and seasonal climate outlook "otherwise" (not "normal or wetter"), or THC "wet" or "normal" and multi-season climate outlook "otherwise" (not "wet to very wet") is changed from base flow to the Caloosahatchee Estuary to "up to level 1 pulse release";

4. Zone C decision tree outcome for THC, seasonal climate outlook, and multi-season climate outlook "dry" is changed from base flow to the Calosahatchee Estuary to "up to level 2 pulse release";

5. Zone D0 for base flow to the Caloosahatchee Estuary is re-defined to discontinue base flow releases if the lake falls below the assumed 12.56 ft elevation for navigation (Lake Okeechobee navigation may be impaired at lower stages) or the current SSM line, whichever is higher (Alternative 1bS2-A17.25 allowed base flow to elevation 11.50 ft at the minimum);

6. Consideration of active huricane season forecast was recommended for inclusion with the THC decision, but this variable was not defined in detail adequate for SFWMM modeling, and it was therefore not included in the Alternative 4 simulation.

OVERVIEW OF THE SFWMM

Brief description of the SFWMM

The SFWMM is an integrated surface water-groundwater model that was developed and is maintained by the SFWMD. The SFWMM simulates the hydrology and water management of southern Florida from Lake Okeechobee to Florida Bay. The SFWMM spans a region of over 7,600 square miles with a 2-mile by 2-mile grid (Figure 13); and simulates the system-wide hydrologic response to daily climatic inputs (rainfall and reference evapotranspiration). Other areas tributary to Lake Okeechobee (e.g. Kissimmee River, C-43 and C-44) are also part of the model, even though they are not explicitly simulated with the 4 square mile grid cells.

The SFWMM simulates infiltration, percolation, evapotranspiration, surface and groundwater flows, levee underseepage, canal-aquifer interaction, well withdrawals for irrigation and/or public water supply, and current or proposed water management structures (canals, spillways, reservoirs, pump, wellfields, etc), and current or proposed operational rules (regulation schedules, drought management plans, etc). The SFWMM is not a succession model: that is, it fixes the land use/cover and associated infrastructure for the entire simulation period. Thus the simulations represent the response of a fixed structural and operational scenario, to historical climatic conditions. This provides a very useful means for comparing the effects of alternative structural and/or operational proposals.

The ability to simulate key water shortage policies affecting urban, agricultural, and environmental water supply facilitates the investigation of tradeoffs between different water demands and sub-regions. Two dimensional regional hydrologic processes are simulated at a daily time step using a mesh of (2 x 2 mile) grid cells producing extensive output that can be summarized into numerous performance measures for plan evaluation. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. The SFWMM (also referred to as the 2x2 model) is the premier hydrologic simulation model used to evaluate regional plans for Everglades restoration and sustainable development in south Florida. Documentation (SFWMD, 2005) including model calibration, verification and peer review can be viewed at http://www.sfwmd.gov/org/pld/hsm/models/sfwmm. Original documentation of the SFWMM was completed in 1984. However, since that time several documentation and peer review efforts have been completed. The documentation and peer review of the model was completed for the current SFWMM version 5.5, in November of 2005. Excerpts from the latest documentation have been included within the report to provide the reader with an introduction to the capabilities of the SFWMM, but the reader should refer to the complete documentation for a complete review of the SFWMM.

Numerical solution

The model uses a daily time step, consistent with the minimum time increment for which input climatic data are available and can be run for time periods ranging from one month to 36 years. A distributed finite difference modeling technique is used to model the gridded portion of the model domain with 2 mile x 2 mile square grid cells. Lumped parameter modeling approaches are used for Lake Okeechobee and the northern lake service areas, which include the Caloosahatchee and St. Lucie Basins. Homogeneity of physical and hydrologic characteristics is assumed within each model grid cell. The grid discretization in the SFWMM is sufficiently fine to describe the solution to the overland and groundwater flow equations with reasonable resolution and to minimize numerical errors (Lal, 1998).

A diffusion wave approximation of the full equations for overland flow from cell-to-cell is solved using an Alternating Direction Explicit (ADE) scheme with four six-hour time slices. Groundwater flow is solved using the vertically-averaged, transient groundwater flow equation with a variation of the unconditionally stable and explicit Saul'yev (1964) method. To minimize bias, the numerical formulation is solved in four different directions in four successive time steps.

Groundwater flow beneath levees is simulated using separate regression equations, based on more detailed 2-dimensional finite element modeling developed to simulate localized levee under-seepage (SFWMD, 2005). To simulate the canals in the system, and to account for changes of storage in the canal due to inflows and outflows, the SFWMM utilizes a mass balance approach. An iteration scheme solves for the equilibrium canal stage each time step. A backwater profile solution scheme is used each time step for the primary canals in the Everglades Agricultural Area (EAA) that are intensively managed by pumping.

Simulation outputs are generally available daily for each canal, structure, and grid cell within the model domain, including existing gage locations. Figure 14 displays the gage locations readily output by the model, and Figure 15 displays the simulated canal network in the SFWMM used for the LORSS. Model output is additionally aggregated for pre-defined groups of adjacent grid cells (indicator regions in Figure 16; additional maps are also available through the Restoration Coordination and Verification (RECOVER) Evaluation Team, at the following web address: http://www.evergladesplan.org/pm/recover/eval_team_maps.cfm) or for larger areas or basins (examples include WCAs and ENP).

<u>Overview of Lake Okeechobee Management Processes in the SFWMM (SFWMD, 2005)</u>

In the SFWMM, Lake Okeechobee is simulated as a lumped hydrologic system as contrasted to the majority of the model domain where a distributed system of 2-mile by 2-mile grid cells is used. There is only one water level that is associated with Lake Okeechobee at any given time step. For each daily time step the water budget equation is solved for Lake Okeechobee. This equation relates the change in storage within the lake as a control volume, and incoming and outgoing flows for the same control volume. Mathematically, lake hydrologic components (rainfall, evapotranspiration and seepage) and managed flows (structure discharges) account for changes in lake storage. Net levee seepage and regional groundwater movement in Lake Okeechobee are assumed to be small relative to the other hydrologic components of the lake water budget and are, therefore, not calculated in the model.

Lake Okeechobee water levels are checked against the defined operational zones. Depending on which zone simulated lake stages fall after adjusting for water supply and storage injection discharges, the additional criteria as defined in the decision tree are applied. In the SFWMM, weekly pre-processed time series data is input and user input options define the thresholds for classification of tributary conditions. Climatic and meteorological forecasts consider several longer-term (up to twelve month) regional, global, and solar indicators in helping to estimate the potential volume of water that can be expected to flow into Lake Okeechobee. As with the tributary conditions, information provided by these indices helps to determine when there is an opportunity to 'hedge' water management practices. The decision tree operational guidelines for WSE (and other similar schedules) utilize three different outlooks in the decision making process: meteorologic forecast, seasonal outlook and multi-seasonal outlook. Each of these measures has an associated classification scheme for determining hydrologic regimes. In the SFWMM, monthly pre-processed non-perfect hind-cast data is input and user options define the thresholds for classification of outlooks. An additional simplifying assumption is made in the model in which the meteorologic forecast is not considered and the seasonal forecast is assumed to apply in both decision boxes. This assumption is necessary due to the difficulty in deriving hind-cast meteorologic forecasts over the 1965-2000 period of simulation.

Examining the WSE "Part 2" decision tree outcomes for discharges to tide, considerable flexibility can be observed in the final determination of discharge volumes. Several of the outcome boxes indicate releases "up to" a determined level. In realtime operations, this allows water managers to optimize the performance of the competing considerations when making regulatory discharges. In the SFWMM, simplifying assumptions are made that enable users to retain some flexibility in determining the operations associated with the decision tree outcome. For boxes that dictate a release "up to" maximum discharge or a determined steady flow, the model will always simulate the maximum allowable flow rate. In the case of decision boxes that indicate "up to maximum pulse release", users have the option of specifying which of the three levels of pulse discharges to make to both the St Lucie and Caloosahatchee Estuaries. Pulse releases are designed to mimic the flow pattern associated with naturally occurring rainfall events and as such should result in less impact to the estuary ecology by allowing time for recovery of the salinity envelope prior to resuming high discharge rates. Once a 10-day outflow pulse is initiated by the schedule, the release rule is continued to completion even if lake stage drops below that pulse level. After a 10-day period is completed, the need for additional releases is re-evaluated.

SFWMM Version to be used

SFWMM v5.5 was used for the LORSS. Version 5.0 and later of the model includes a major effort to upgrade the model including adding an additional five years of climatic data from 1996-2000, updating land-cover for 2000 conditions, reviewing methods to estimate potential evapotranspiration, and updating rainfall data used. Complete documentation is available on the SFWMD webpage for the SFWMM: http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/ (SFWMD, 2005).

Period of simulation

The SFWMM produces daily output for a 36-year period of record (POR): 1965-2000.

<u>Strengths and Weaknesses of the SFWMM</u>

The major strength of the SFWMM is that it is a regional integrated surface water/groundwater model covering a large portion of south Florida. The model is well-suited to modeling of the hydrologic conditions which characterize south Florida, including the flat terrain, high water table, and high aquifer transmissivity. The SFWMM has been used in the past for project analysis, and the model is familiar to many interested stakeholders. Particular strengths of the SFWMM include:

a. It is capable of simulating the interdependency between hydrology and management (operations), and among different components of the regional system.
b. Canal routing, overland flow, unsaturated zone mass balance, two-dimensional single-layer aquifer flow, spatially-distributed rainfall, and evapotranspiration are included in the model.
c. Hydrologic impacts on agriculture, urban, and environmental areas can be jointly evaluated through the use of comprehensive, post-processed model output.
d. The SFWMM is a useful tool in evaluating long-term and short-term effects of management decisions. A 36-year POR for rainfall data (1965-2000) can be simulated in a short runtime of less than two hours.
e. Regional impacts of hydraulic infrastructure changes are readily evaluated with the suite of model output.
f. Routines are readily available for modifying model output into performance measure sets, useful tools for comparing regional and area-specific performance of several alternatives.
g. The SFWMM can provide guidance as to where future data collection and additional modeling efforts should proceed. SFWMM can effectively be used as a regional-scale screening tool to help identify locations and particular years when finer-scale analysis may be needed.

The weaknesses of the SFWMM are related mostly to the sub-regional or localized applicability of the model. The two-mile by two-mile grid cells are described by a single average value for all hydrologic characteristics, including land surface elevation, storage coefficient, permeability, infiltration rate, and roughness coefficient.

Other weaknesses or limitations (that would also apply to other similar models) include:

a. Model scale is too coarse for studies/investigations that require finer detail of local hydrologic response, for example drawdown analyses and localized levee seepage. Subtle gradients in topography (at a scale smaller than two miles) that may have ecological implications cannot be represented in the model. The coarse scale of SFWMM limits but does not discount its utility for quantifying potential flood impacts. The SFWMM is not appropriate for detailed farm-scale flood analysis but is appropriate for identifying potential regional flooding impacts.
b. Groundwater equations are simplified under the assumption of two-dimensional flow, such that transmissivity, storage coefficient, recharge, and hydraulic head can be vertically averaged. The model's solution to the general groundwater flow equations represents regional groundwater flow while empirical levee seepage equations are used to solve for levee seepage.

c. Quality assurance/quality control (QA/QC) of the model output and performance measure sets is difficult due to the regional nature of the model and the resultant size of the performance measure set. This activity usually requires substantial staff time.
d. Model was calibrated for stage at monitoring points and control structure flow. The model is not calibrated for overland flow. Note however that the state-of-the-art in modeling and data collection do not allow calibration of any regional scale model to overland flow or groundwater flow volumes. In versions of the SFWMM prior to version 5.0, the comparison of simulated versus historical water levels were compared on an end-of-week, not a daily, basis. For SFWMM V5.0 and later, calibration for stage in marsh gages is done on a daily time step, while canals are evaluated on a weekly basis.
e. Intended use of the model is to provide long-term planning-type guidance to water managers with regards to making water policy decisions. The SFWMM is not intended to estimate system responses to extreme conditions whose timing may be on the order of hours or even minutes.
f. Structure operations are subject to a limited degree of operational flexibility given code and input limitations. The inclusion of complex operational rules may not be possible for all structures. Operational rules for a control structure may change from wet season to dry season, but operations must remain constant for the POR simulated.

<u>Parameter Uncertainty within the SFWMM</u>

The following discussion regarding parameter uncertainty, with specific application for SFWMM performance measures, has been excerpted from the draft RECOVER Comprehensive Everglades Restoration Plan (CERP) System-wide Performance Measures report (RECOVER, 2006).

Parameter uncertainty is estimated by running a series of SFWMM simulations using historic flows assigned at major control structures where reliable flow records exist. Parameters are incrementally varied one at a time from the original calibrated parameters to estimate the 90 percent certainty band for each parameter. The compartmentalization of south Florida's hydrologic system by structures and levees presents a unique situation that allows the effects of varying individual parameters within several regional compartments at the same time. The same parameter value is applied everywhere the physical characteristic is the same, restricting the range in which a specific parameter value may be varied without causing major impacts to the calibration of one or more compartment. The effect of compartmentalization is to reduce uncertainty associated with selection of parameter values. The uncertainty of a given model output variable can be represented by the half-width of the 90 percent uncertainty band. The general rule is the narrower the bands, the greater the level of certainty.

The estimate of performance measure uncertainty was made with version 2.4 of the SFWMM. Structural flows were estimated based on operational rules in place at the time of the simulations (1995) for the high and low values recommended from sensitivity analysis. Parameter uncertainty was estimated by comparing water levels measured at a particular site to those simulated with the calibration version (historical flows assigned to major structures) of the SFWMM for the 2-by-2 mile cell that contains the measurement site. A large portion of the uncertainty that exists in simulated water levels in this analysis is associated with scaling, process aggregation, the location of the gauging site within the cell, and estimates of regional rainfall and evapotranspiration. These types of uncertainty can be reduced by considering 1) regional performance measures that include model output simulated at several cells and 2) relative benefits of system performance measures between an alternative and the base condition or between alternatives. When considering uncertainty of simulated performance measures, it is important to realize that the certainty of meeting individual performance measures depends on the priority that a particular water management objective has relative to other water management objectives. Therefore, simulated performance measure uncertainty associated with the SFWMM is estimated by replacing the historical flows of the calibration version of the model with simulated flows estimated within the operational version of the model and varying the parameters. The same exercise would need to be completed for each alternative as performance measure uncertainty will vary with each alternative. This can require a great deal of effort that may not be practicable when considering the cost-benefit ratios of taking on such a task and considering that other causes of uncertainty outside the modeling realm may be greater than those of the modeling realm. A large portion of uncertainty that exists in estimating performance measures is caused by such factors as natural climate variability, anthropogenic climate change, and sea level rise.

SIMULATION ASSUMPTIONS

Baseline Assumptions

As a result of the current LORSS, a new regulation schedule is expected to be in place by January of 2007. Soon after that time, a new LORSS will be initiated with an expected duration of approximately three years, at which time a new regulation schedule is anticipated for operation with the Acceler8 and CERP Band 1 projects. Therefore, the baseline assumptions for SFWMM modeling of the No Action Alternative includes the existing water mangement structures plus those expected to be in place prior to January 2007:

- 2000 land use and associated irrigation demands for the Lower East Coast Service Area (LECSA). The LECSA includes the developed portions of Palm Beach, Broward, and Dade Counties.
- 2000 public water demands at the existing wellfields.
- 2005 water management facilities and associated operating procedures, including Interim Operational Plan (IOP) operations for WCA 3A and South Dade County in the Lower East Coast.
- Current regulation schedules for Kissimmee Chain of Lakes, WCA 1, WCA 2A and WCA 3A, with the WSE regulation schedule for Lake Okeechobee.
- Temporary forward pumps as proposed by the SFWMD.
- Stormwater treatment area (STA)-3/4 treatment capacity of approximately 64,000 acre-feet (average annual), assumed based on current nutrient levels in Lake Okeechobee

The baseline model (also referenced as the No Action Alternative or LORSS 2007) was developed from the available SFWMM model determined by the LORSS Project Delivery Team as the closest representation of the existing conditions prior to implementation of the new LORSS. The LORSS baseline model and all alternatives were developed from the SFWMM modeling previously completed by the SFWMD for the 2005 Lower East Coast Regional Water Supply Plan (LECRWSP). The detailed list of assumptions for the 2005 LECRWSP, as used for the LORSS baseline, are included as Appendix B.

Although not specifically mentioned in the description of the alternative Lake Okeechobee operational schedules, the simulation of all LORSS baseline modeling and alternatives assumed pumping to the WCAs unconditionally when the lake levels are in the highest zone (Zone A, or White band for Alternative 2a-B and Alternative 2a-m). The assumed treatment capacity constraint for STA-3/4 is simulated in the SFWMM by restricting the wet and dry season conveyance capacities for the Miami and North New River canals to pass approximately 58,500 acre-feet, average annual during the dry season and 4,700 acre-feet, average annual during the wet season from Lake Okeechobee to the STA-3/4.

SIMULATION RESULTS

An enormous amount of output is generated from each SFWMM simulation and post-processed Performance Measures and Indicatiors. Selected graphical summaries of the performance of each are presented in Appendix A and discussed in this section. The complete set of performance measure output for all alternatives evaluated under this study is available on the Corps web page for Lake Okeechobee Regulation Schedule Modeling, at the following web address: http://hpm.sfrestore.org/loweb/sfwmm/.

The best hydrologic performance measures are those which provide a quantitative indication of how well (or poorly) an alternative meets a specific objective. These hydrologic performance measures are useful surrogates for ecosystem benefits and impacts. Although not presented herein, further evaluations of the results from water quality, ecological, and economic perspectives will be performed as part of the LORSS. Because it was not possible to include all seven alternatives (plus the No Action Alternative) into one graphical plot, three plots having the same performance measures are generated to show the appropriate comparisons. Simulation results for all alternatives, compared to the No Action Alternative, are summarized for the following regions: Lake Okeechobee, Estuaries and Bays (includes Caloosahatchee and St. Lucie Estuaries), WCAs and Everglades National Park (ENP) Flows, and Water Supply. Table 2 summarizes the naming convention used to display the performance measures for each alternative, as names are limited to 6-8 characters.

TABLE 2: PERFORMANCE MEASURE LABELS FOR ALTERNATIVES

Alternative	PM data label
no action alternative	07LORS
LORS-FWO alternative	lors-fwo
alternative 1bS2-A17.25	a1bS2-A
alternative 1bS2-m	a1bS2-m
alternative 2a-B	alt2a-B
alternative 2a-m	alt2a-m
alternative 3-B	alt3-B
alternative 4-A17.25	alt4-A

Lake Okeechobee

A review of the simulation output for Lake Okeechobee requires consideration of a wide range of performance metrics including flood protection, lake ecology, and navigation. Figures 17-24 show examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: http://hpm.saj.usace.army.mil/loweb/sfwmm.

A. Regulatory Releases

An overview of the trends of alternative performance is captured from a review of the performance measure showing average annual flood control releases from Lake Okeechobee and the associated distribution to tidewater through the L-8 canal, the St. Lucie Estuary through S-308, the Caloosahatchee Estuary through S-77, and south to the WCAs through S-351 (to the Hillsborough and North New River Canals) and S-354 (to the Miami River Canal), which are shown in Figures 17-19. Ranking the alternatives with respect to average annual flood control discharge to the St. Lucie Estuary, the following trend is observed (highest to lowest): Alternative 2a-m; Alternative 2a-B; Alternative 4-A17.25; Alternative 3-B; No Action Alternative (labeled as 07LORS in all performance measure graphics); LORS-FWO and Alternative 1bS2-m; and lastly Alternative 1bS2-A17.25. Ranking the alternatives with respect to average annual flood control discharge to the Caloosahatchee Estuary, the following trend is observed (highest to lowest): Aalternative 2a-m; Alternative 4-A17.25; Alternative 2a-B; Alternative 1bS2-m; Alternative 1bS2-A17.25; No Action Alternative; LORS-FWO; and lastly Alternative 3-B. Generally, the alternatives that most significantly lower the lake stages result in the most significant increase in discharge volume to the estuaries. This point is emphasized by the assumption of the treatment capacity constraint for STA-3/4, which is utilized to limit the average annual volume of lake regulatory releases passed south to STA-3/4 from S-351 and S-354 to a comparable volume for the no action condition and all evaluated LORS Alternatives. Potential changes in flows to the estuaries will be later discussed in this section.

B. Stage Duration Curves: Flood Protection and Navigation

The stage duration curve for Lake Okeechobee is also a key indicator of relative alternative performance (Figures 20-22). Two alternatives, LORS-FWO and Alternative 3-B, demonstrate a trend to reduce lake stages by approximately 0.1 to 0.5 feet compared to the current WSE regulation schedule (the No Action Alternative). Three alternatives, Alternative 1bS2-A17.25, Alternative 1bS2-m, and Alternative 4-A17.25, demonstrate a trend to reduce lake stages by approximately 1.0 to 1.2 feet. Two alternatives, Alternative 2a-B and Alternative 2a-m, demonstate a trend to reduce lake stage by greater than 1.2 feet, up to approximately 1.5 feet. Peak stages for the No Action and alternatives are summarized as follows: 18.50 ft, NGVD for the No Action Alternative; 18.03 ft for Alternative LORS-FWO; 17.48 ft for Alternative 1bS2-A17.25; 17.23 ft for Alternative 1bS2-m; 17.13 ft for Alternative 2a-B; 17.05 ft for Alternative 2a-m; 18.04 ft for Alternative 3-B; and 17.22 ft for Alternative 4-A17.25. Three of the alternatives plus the No Action Alternative show simulated stages above 17.25 ft, NGVD: 331 days for the No Action Alternative; 59 days for LORS-FWO; 12 days for Alternative 1bS2-A17.25; and 107 days for Alternative 3 (note: 13,149 days in the SFWMM 36-year period-of-record). Aviodance of the 17.25 ft elevation offers additional protection for public safety and the Herbert Hoover Dike. Extreme high lake stages have also been documented to adversely impact the plant and animal communities, through processes which include the following: physical uprooting of emergent and submerged plants; reduced light levels in the water column due to increased suspended sediment; and littoral zone exposure to increased nutrient levels from the water column. The frequency of occurence for lake stages above 16.0 ft, 16.5 ft, 17.0ft, and 17.25 ft are summarized in Figure 23.

Alternatives observed to most significantly reduce the extreme high water stages for Lake Okeechobee (upper 10% of the stage duration curve) also show the most significant reduction in lake stages during dry conditions (bottom 10% of the stage duration curve). Increased fequency of low water conditions can adversely impact the health of the Lake Okeechobee littoral zone through increased susceptibility to fire and drought conditions, habitat loss, expansion of exotic and invasive vegetation, and oxidation of organic soils. The minimum simulated stages for Lake Okeechobee are summarized as follows: 9.61 ft for the No Action Alternative; 9.11 ft for LORS-FWO; 8.88 ft for Alternative 1bS2-A17.25; 8.82 ft for Alternative 1bS2-m; 8.36 ft for Alternative 2a-B; 8.27 ft for Alternative 2a-m; 9.07 ft for Alternative 3-B; and 8.42 ft for Alternative 4-A17.25. Increased frequency of low water conditions may also potentially impact recreational and commercial navigation and availability of lake supply for water supply needs. The number of days below 12.56 ft elevation is stated in the following summary: 2577 days for the No Action Alternative; 3336 days LORS-FWO; 4809 for Alternative 1bS2-A17.25; 4842 days for Alternative 1bS2-m; 5141 days for Alternative 2a-B; 5776 days for Alternative 2a-m; 3260 days for Alternative 3-B; and 4841 days for Alternative 4-A17.25.

C. Lake Okeechobee Ecology: Extreme High Stage, Extreme Low Stage, Stage Envelope

RECOVER is an arm of the CERP responsible for linking science and the tools of science to a set of system-wide planning, evaluation and assessment tasks. The most current (as of March 2006) RECOVER performance measures for Lake Okeechobee: extreme low lake stage, Lake Okeechobee extreme high lake stage, and Lake Okeechobee stage envelope, were utilized to evaluate the alternatives of the LORSS effort. In-depth documentation and rationale for these performance measures is available through the RECOVER performance measure documentation in the draft RECOVER CERP System-wide Performance Measures report (RECOVER, 2006), at the following web address: www.evergladesplan.org/pm/recover/eval_team_perf_measures.cfm. Extreme low and extreme high lake stage are evaluated with response curves. For extreme low lake stage, zero weeks below 10 ft, elevation NGVD responds to a score of 100, and 540 weeks or greater with stages below 10 ft responds to a worst case situation (15 weeks per year over 36 year simulation period), with scores linearly varied between the two extremes. For extreme high lake stage, zero weeks above 17 ft elevation responds to a score of 100 and 396 weeks or greater with stages above 17 weeks responds to the assumed worst case situation (11 weeks per year), with scores linearly varied between the two extremes. The resultant standard scores for extreme low and high lake stage are summarized as follows, with low score followed by high score: 99/83 for the No Action Alternative; 95/90 for LORS-FWO; 87/99 for Alternative 1bS2-A17.25; 87/99 for Alternative 1bS2-m; 83/100 (rounded up) for Alternative 2a-B; 78/100 (rounded up) for Alternative 2a-m; 92/85 for Alternative 3-B; and 85/99 for Alternative 4-A17.25.

The stage envelope performance measure similarly documents the benefits of seasonally-variable water levels within the range of 12.5 ft (June-July low) and 15.5 ft (November-January high) on the plant and animal communities of Lake Okeechobee. The conceptualization of the optimal stage envelope seasonal variation is shown in Figure 24 (the comparison actually utilizes smoothed boundaries for the upper and lower envelope); in simplified terms, penalty points are assigned to each alternative based on deviations outside of the envelope, with increased penalty points with increased distance away from the optimal envelope. The worst case scenario for variability above the stage envelope is assumed to be one where the lake stage hydrograph is always in the poor zone (1.0 ft outside of the stage envelope), which equates to a total score of 1872 foot-weeks; the response curve is a line between 0 (target, score of 100) and 1872 foot-weeks (score of 0). For deviation of lake stage below the envelope, the target is 192 weeks. This is the score that would be obtained if all years had hydrographs within the optimal zone, except for once per decade the stage falling to just below 11 ft elevation for an average of three months. The response curve is a line between 192 (192 foot-weeks or less receives a score of 100) and 1872 foot-weeks (worst case scenario receives a score of zero). The resultant standard scores for lake daily stage (RECOVER performance measure specified weekly stage, but only daily stage comparisons are available within the LORSS evaluation timeframe) above and below the stage envelope are summarized as follows, with the above score followed by the below score: 75/56 for the No Action Alternative; 63/62 for LORS-FWO; 34/80 for Alternative 1bS2-A17.25; 33/82 for Alternative 1bS2-m; 24/90 for Alternative 2a-B; 9/94 for Alternative 2a-m; 60/53 for Alternative 3-B; and 28/86 for Alternative 4-A17.25. The percentage of time within the stage envelope was also identified for all alternatives as comparable, ranging within a narrow band from 25 percent (Alternative 3) to 32 percent (Alternative 2a-B) of the 36-yearPOR. Given the similiarity of time within the stage envelope band, additional focus was placed on the deviation of stages when outside the stage envelope band; alternatives observed to most significantly reduce the extreme high water stages for the lake will score better for the stage envelope above and tend to score lower for the stage envelope below.

Estuaries and Bays

One of the objectives for managing Lake Okeechobee levels was to reduce the number of high regulatory discharges to the Caloosahatchee and St. Lucie Estuaries. Recognizing the need to lower the high lake levels, a strategy was incorporated into the alternatives to make more low-level (environmentally friendly) releases to avoid the high-level regulatory releases. Figures 25-39 show examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: http://hpm.saj.usace.army.mil/loweb/sfwmm.

A. Caloosahatchee Estuary

For all the alternatives, the mean monthly flows between 2800 and 4500 cfs were essentially the same or decreased. For mean monthly flows greater than 4500 cfs, only two alternatives had the same or less events: LORS-FWO and Alternative 3-B. The rest of the alternatives had an increase of two to three events of high flow with the exception of Alternative 2a-B which had an increase of seven events of high flow. The base condition and all alternatives were about five times greater than the target for high flows.

In addition to the number of mean monthly flows, the duration of high-flow releases (consecutive months of >4500 cfs) are of concern. All of the alternatives showed significant differences in the duration of mean monthly high-flow events. A discussion of the longest duration of the total estuary high-flow will be presented here. The worst case for No Action Alternative (base run) was 24 periods of 2 to 3 months duration of high-flow. The worst case for LORS-FWO was 23 periods of 2 to 3 months duration of high-flow. The worst case for Alternative 1bS2-A17.25 was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 1bS2-m was 4 periods of 4 to 5 months duration of high-flow. The worst case for

A1ternative 2a-B was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 2a-m was 4 periods of 4 to 5 months duration of high-flow. The worst case for Alternative 3-B was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 4-A17.25 was 7 periods of 6 to 7 months duration of high-flow.

For the mean monthly flows less than 300 cfs, all the alternatives significantly reduced the number of events (by almost half the number). Alternatives Alternative 2a-B, Alternative 2a-m and Alternative 4-A17.25 showed the least improvement.

B. St. Lucie Estuary

For all the alternatives, the mean monthly flows between 2000 and 3000 cfs were nearly the same or decreased. For mean monthly flows greater than 3000 cfs, the alternatives had mixed results. For LORS-FWO, Alternative 1bS2-A17.25, Alternative 1bS2-m, Alternative 3-B, and Alternative 4-A17.25 there was a slight reduction of high-flow events. Only Alternative 2a-B and Alternative 2a-m had a greater number of flow events greater than 3000 cfs. The base condition and all alternatives were two to three times greater than the target for high flows.

In addition to the number of mean monthly flows, the duration of high-flow releases (consecutive months of >3000 cfs) are of concern. All of the alternatives showed differences in the duration of mean monthly high-flow events. A discussion of the longest duration of the total estuary high-flow will be presented here. The worst case for No Action Alternative (base run) was 6 periods of 6 to 7 months duration of high-flow. The worst case for LORS-FWO was 9 periods of 4 to 5 months duration of high-flow. The worst case for Alternative 1bs2-A17.25 was 8 periods of 4 to 5 months duration of high-flow. The worst case for Alternative 1bS2-m was 7 periods of 6 to 7 months duration of high-flow. The worst case for A1ternative 2a-B was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 2-m was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 3-B was 7 periods of 6 to 7 months duration of high-flow. The worst case for Alternative 4-A17.25 was 8 periods of 4 to 5 months duration of high-flow.

For the mean monthly flows less than 350 cfs, the minimum flow needs were generally thought to be met by intervening flows (including groundwater flows). With regard to releases from S-80, most alternatives had essentially the same number of low-flow months as the base case. There were three notable differences: Alternative 2a-B and Alternative 3-B had more low-flow months while Alternative 2a-m had fewer low-flow events.

C. Lake Worth Lagoon

For all the alternatives, the number of times the two-day moving average flow was greater than 1000 cfs decreased. The number of times the seven-day moving average flow was greater than 500 cfs were nearly the same except for slight increase in LORS-FWO, Alternative 2a-B and Alternative 2a-m. The number of times the seven-day moving average flow was equal to zero remained unchanged for all alternatives.

D. Biscayne Bay

Flows to Biscayne Bays were essentially unchanged (± 1 to 2 kaf/yr) in all the alternatives.

E. Whitewater Bay

For most alternatives, there was less than a 3 kaf/yr reduction in overland flow. However, Alternative 4-A17.25 and Alternative 2a-m had a 4 and 5 kaf/yr reduction in overland flow, respectively.

F. Florida Bay

Flows to Biscayne Bays were essentially unchanged (+ 1 kaf/yr at most) in all the alternatives.

WCA and ENP Flows

The flow changes, as related to the various alternatives, in the WCAs and ENP are discussed in this section. Generally, the flow changes (as indicated by the transect flows) in these areas are relatively small. As a result of greater-than-normal lake mixing from recent hurricanes, the STA-3/4 flow constraint of approximately 63,000 acre-feet/yr reduces the amount of flow from Lake Okeechobee that normally goes directly to WCA 3A; this is because of the increased loading that could occur due to an increased suspension of nutrients in Lake Okeechobee. The STA-3/4 flow constraint is included in all the alternatives as well as in the no action base condition. Figures 40-42 show examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: http://hpm.saj.usace.army.mil/loweb/sfwmm.

A. WCA 1

Flows across Transect T1 show little variation (± 1 kaf/yr) in all the alternatives.

B. WCA 2A

Flows across Transect T2 show some variation in the alternatives. Alternative 1bS2-A17.25 and Alternative 1bS2-m show an increase of about 6 kaf/yr; LORS-FWO, Alternative 2a-B and Alternative 3-B show little change (-1 or -2 kaf/yr); and Alternative 2a-m and Alternative 4-A17.25 show a decrease in flow (-5 and -6 kaf/yr).

C. WCA 3A

Flows across central WCA 3A (Transects T6 and T7) show slight variations between alternatives. Alternatives LORS-FWO, 1bS2-A17.25, 1bS2-m, 2a-B and 3-B show overland flow differences of about ± 3 kaf/yr. Alternatives 2a-m and Alternative 4-A17.25 show decreases of -13 kaf/yr and -7 kaf/yr.

D. ENP

Overland flows into ENP are shown as Transects T17 and T18. LORS-FWO decreases flow (-4 kaf/yr); Alternative 1bS2-A17.25 increases flow (2 kaf/yr); Alternative 1bS2-m shows no change; Alternative 2a-B decreases flow (-6 kaf/yr); Alternative 2a-m decreases flow (-13 kaf/yr); Alternative 3-B decreases flow (-4 kaf/yr); Alternative 4-A17.25 decreases flow (-9 kaf/yr).

Water Supply

All alternatives evaluated, including the No Action Alternative, assume operation of the SFWMD temporary forward pumps for water supply at S-354 (400 cfs), S-351 (600 cfs), and S-352 (400 cfs). Based on preliminary operational guidance from the SFWMD, the pumps are simulated to trigger on for water supply demands if Lake Okeechobee stage falls below 10.2 ft; the pumps are assumed triggered off when Lake Okeechobee stage recovers to 11.2 ft. The No Action Alternative assumes the existing SSM line (set by the SFWMD) to be in place. Based on guidance from the SFWMD, a modified SSM line and operations are anticipated to be implemented in advance of any new regulation schedule resultant from LORSS; all alternatives, therefore, assume a 1.0 ft lowering of the existing SSM line as a surrogate for the anticipated SSM changes by the SFWMD (this assumption is based on a recommendation from the SFWMD). The No Action Alternative is the only alternative to utilize the existing SSM line. In order to provide additional data related to the assumed lowering of the SSM line, a sensitivity model run was completed for the Preferred Alternative with the SSM line returned to the existing (same as the No Action Alternative) level.

Three performance measures are presented to compare the potential water supply impacts of the alternatives. Particular emphasis is given to water supply impacts under the most significant drought conditions experienced within the simulation POR, as water supply needs under drought conditions are highly susceptible given the observed lowering of Lake Okeechobee stages under the alternatives. Figures 43-48 show examples of the modeling results as related to the following discussion. All of the figures can be reviewed at: http://hpm.saj.usace.army.mil/loweb/sfwmm.

A. Everglades Agricultural Area

Simulated water supply effects to the EAA are shown based on the performance measure for mean annual EAA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demand not met indicative of higher potential impacts to EAA water supply: 27,000 acre-feet of demand not met for LORS-FWO (6% of total demand is not met); 37,000 acre-feet for Alternative 3-B (8% not met); 44,000 acre-feet for the No Action Alternative (10% not met); 67,000 acre-feet for Alternative 1bS2-A17.25 (15% not met); 73,000 acre-feet for Alternative 1bS2-m (16% not met); 84,000 acre-feet for Alternative 4-A17.25 (18% not met); 103,000 acre-feet for Alternative 2a-B (22% not met); and the highest of 134,000 acre-feet for Alternative 2a-m (27% not met).

B. Lake Okeechobee Service Area

Simulated water supply effects to the Lake Okeechobee Service Area (LOSA) are shown based on the performance measure for mean annual LOSA Supplemental Irrigation, demands and demands not met. The alternatives are ranked in order of the mean annual volume of demands not met during the drought years of 1971, 1975, 1981, 1985, and 1989, with increased demands not met indicative of higher potential impacts to LOSA water supply: 15,000 acre-feet of demand not met for LORS-FWO (5% of total demand is not met); 18,000 acre-feet for Alternative 3-B (5% not met); 24,000 acre-feet for the No Action Alternative (7% not met); 28,000 acre-feet for Alternative 1bS2-A17.25 (8% not met); 30,000 acre-feet for Alternative 1bS2-m (9% not met); 39,000 acre-feet for Alternative 4-A17.25 (11% not met); 45,000 acre-feet for Alternative 2a-B (13% not met); and the highest of 56,000 acre-feet for Alternative 2a-m (17% not met).

C. Lower East Coast

Simulated water supply effects to the Lower East Coast are shown based on the number of months of water supply cutbacks for the 36-year POR. The performance measure graphics selected show the number of months under cutback (all cutbacks are phase 1 cutbacks for the LORSS Alternatives) for each of the following LECSA: Northern Palm Beach County, LECSA1, LECSA2, and LECSA3. Phase 1 cutbacks can be induced by one of three triggers: Lake stage in SSM Zone (indicated by upper label on the figures), local trigger well stages (lower data label; as expected, this changes minimally for the regulation schedule alternatives), or dry season criteria (indicated by the middle data label; phase 1 restrictions remain in place until the end of the dry season if water restrictions from the Lake or local groundwater triggers occurred anytime during the dry season). For LECSA Northern Palm Beach County, the No Action Alternative shows 31 months of simulated cutbacks; slight increases to 33 months are observed in the simulation results for Alternative 1bS2-A17.25, Alternative 1bS2-m, Alternative 2a-B, Alternative 2a-m, and Alternative 4-A17.25; significant reduction of cutback months are observed with 16 months under cutback for the LORS-FWO alternative and Alternative 3-B. The same trend is observed in the simulation results for LECSA1, LECSA2, and LECSA3. The No Action Alternative simulation results show 31 cutback months for LECSA1, 80 cutback months for LECSA2, and 31 cutback months for LECSA3. Alternatives 1bS2-A17.25, 1bS2-m, a2a-B, 2a-m, and Alternative 4-A17.25 slight increases to 33 cutback months for LECSA1, 82 cutback months for LECSA2, and 33 cutback months for LECSA3. Alternative LORS-FWO and Alternative 3-B show a significant reduction to 16 cutback months for LECSA1, 71 cutback months for LECSA2, and 16 cutback months in LECSA3.

D. SSM Sensitivity Simulation

The above general overview of water supply performance measure trends is dependent on the assumption for the SSM line. As previously summarized, modified SSM line and operations are anticipated to be implemented in advance of any new regulation schedule resultant from LORSS; all alternatives (with the exception of the no action baseline alternative), therefore, assume a 1.0 ft lowering of the existing SSM line as a surrogate for the anticipated SSM changes by the SFWMD. Generally, the inclusion of the temporary forward pumps allows for the assumption of the lowered SSM line, meaning that water supply restrictions would be initiated at lower lake stages than currently in practice. Additional data is available for the evaluation of the Preferred Alternative (Alternative 1bS2-m) through a sensitivity model simulation with the existing SSM line assumed in place (consistent with the No Action Alternative). The assumed lowering of the SSM line does alter the performance of the Preferred Alternative. With the existing SSM line assumed in place with the operational rules of Alternative 1bS2-m, the simulation results show mean annual EAA supplemental demands not met to increase from an average annual volume of 22,000 acre-feet and average drought year (1971, 1975, 1981, 1985, and 1989) volume of 73,000 acre-feet under Alternative 1bS2-m to an average annual volume of 42,000 acre-feet and average drought year volume of 114,000 acre-feet; the percentage of demands not met for the EAA is increased from 6 to 12 percent for the average year and 16 to 24 percent during the drought years. With the existing SSM line assumed in place with the operational rules of Alternative 1bS2-m, the simulation results show mean annual LOSA supplemental demands not met to increase from an average annual volume of 10,000 acre-feet and average drought year volume of 30,000 acre-feet under Alternative 1bS2-m to an average annual volume of 23,000 acre-feet and average drought year volume of 56,000 acre-feet; the percentage of demands not met for the LOSA is increased from four to ten percent for the average year and 9 to 17 percent during the drought years. The number of months of simulated water supply cutbacks for the four LEC service areas also show increased cutback months for the Preferred Alternative without the assumption of a lowered SSM line: 33 to 49 months for Northern Palm Beach County; 33 to 49 months for LECSA1; 82 to 95 months for LECSA2; and 33 to 49 months for LECSA3. Select performance measures have been summarized; the complete performance measure set is available on the study web page previously cited (the performance measure set includes “alt1bS2-m-exSSM” in the title and the abbreviation of “mexSSM” on the performance measure set graphics). The SSM Line is set by the SFWMD. Modified SSM rules and a modified SSM line are under development by the SFWMD; these efforts are anticipated to be completed prior to implementation of any new regulatory schedule for Lake Okeechobee, and the efforts will be able to consider the additional data provided from the Preferred Alternative for LORSS. The water supply effects of the alternatives, as shown by a review of the performance measures, must be evaluated with consideration of this parallel and ongoing effort by the SFWMD. The performance measure output is dependent on the SSM line assumption; modification of the SSM line or existing SSM rules (as assumed in place under all alternatives evaluated) will affect the simulated performance, and the nature of the changes will determine the significance of the observed improvement or potential additional impact seen in the simulation results.

SUMMARY

The No Action Alternative, along with seven other alternatives, were modeled using the SFWMM. The modeling intent and differences of the alternatives were presented. Examples of the output and post-processed products (Appendix A) were used as part of the overall considerations to select a TSP, i.e. Preferred Alternative.

REFERENCES

Lal, A.M.W. 1998. Performance Comparison of Overland Flow Algorithms. *Journal of Hydraulic Engineering,* ASCE, Volume 124, Number 4, April 1998, pp. 342-349.

Restoration Coordination and Verification (RECOVER). March 16, 2006. Comprehensive Everglades Restoration Plan System-wide Performance Measures, RLG Review Draft. Comprehensive Everglades Restoration Plan, Central and Southern Florida Project. http://www.evergladesplan.org/pm/recover/eval_team_perf_measures.cfm.

Saul'yev V.K. 1964. *Integration of Equations of Parabolic Type by the Methods of Nets.* New York, New York: Pergamon Press.

South Florida Water Management District (SFWMD) and the Interagency Modeling Center. November 2005. Final Documentation for the SFWMM (v5.5). South Florida Water Management District, West Palm Beach, Florida.

ATTACHMENT A

Selected Performance Measures and Indicators

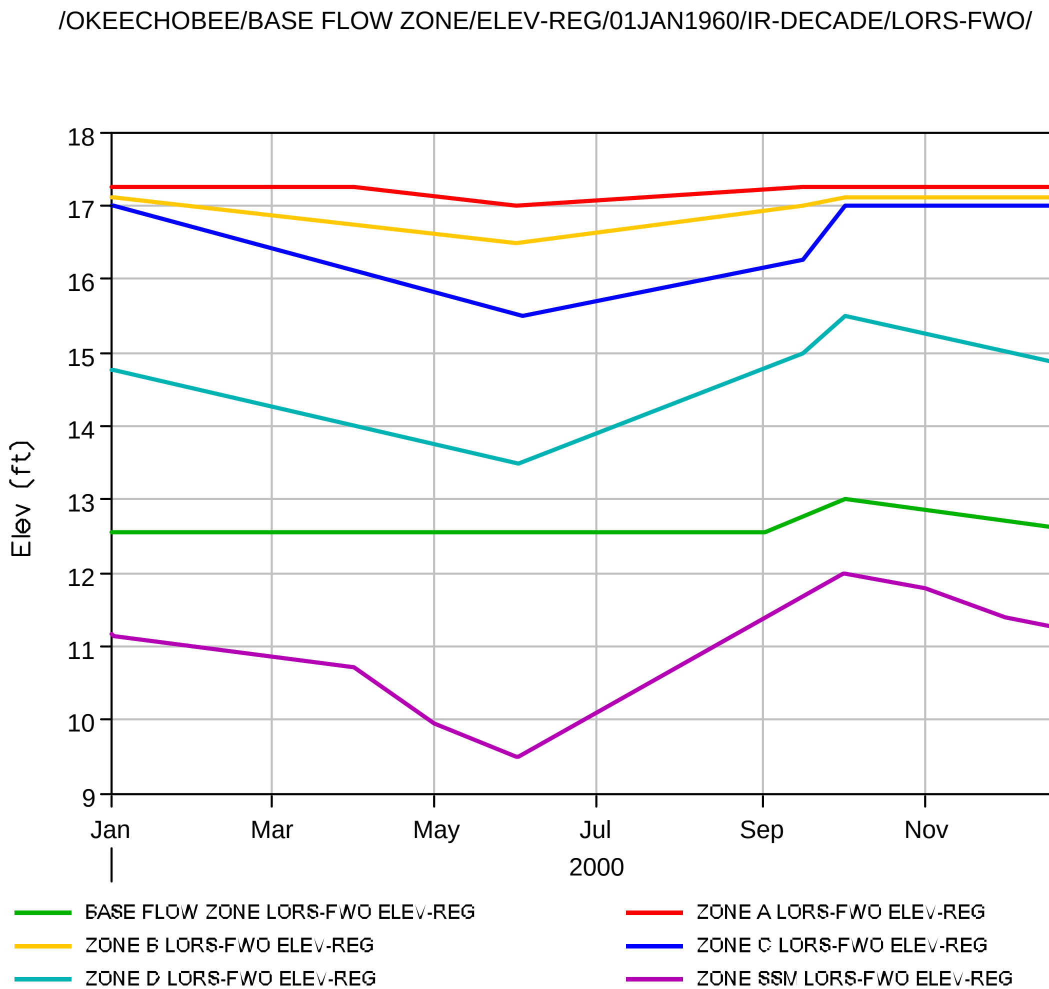


FIGURE 1: REGULATION SCHEDULE FOR ALTERNATIVE LORS-FWO

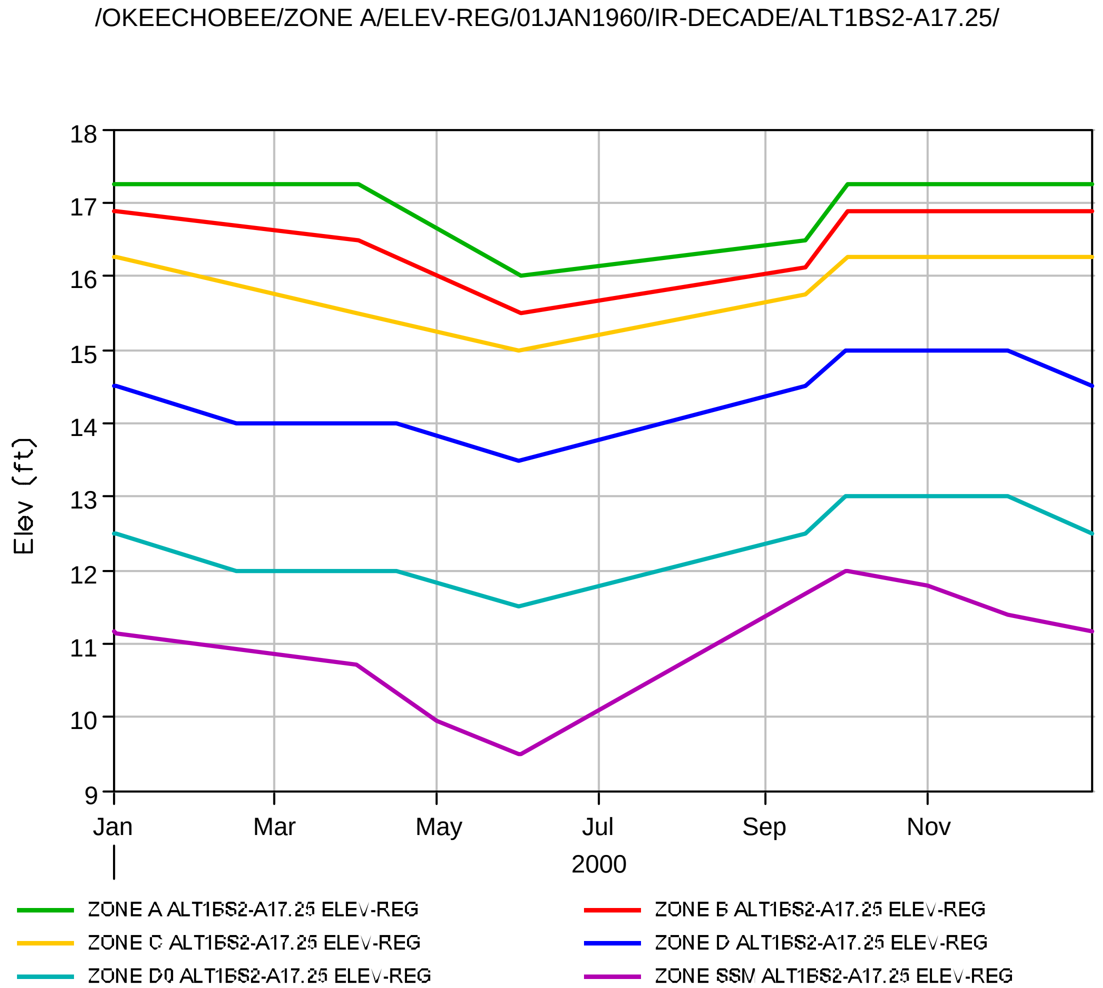


FIGURE 2: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-A17.25

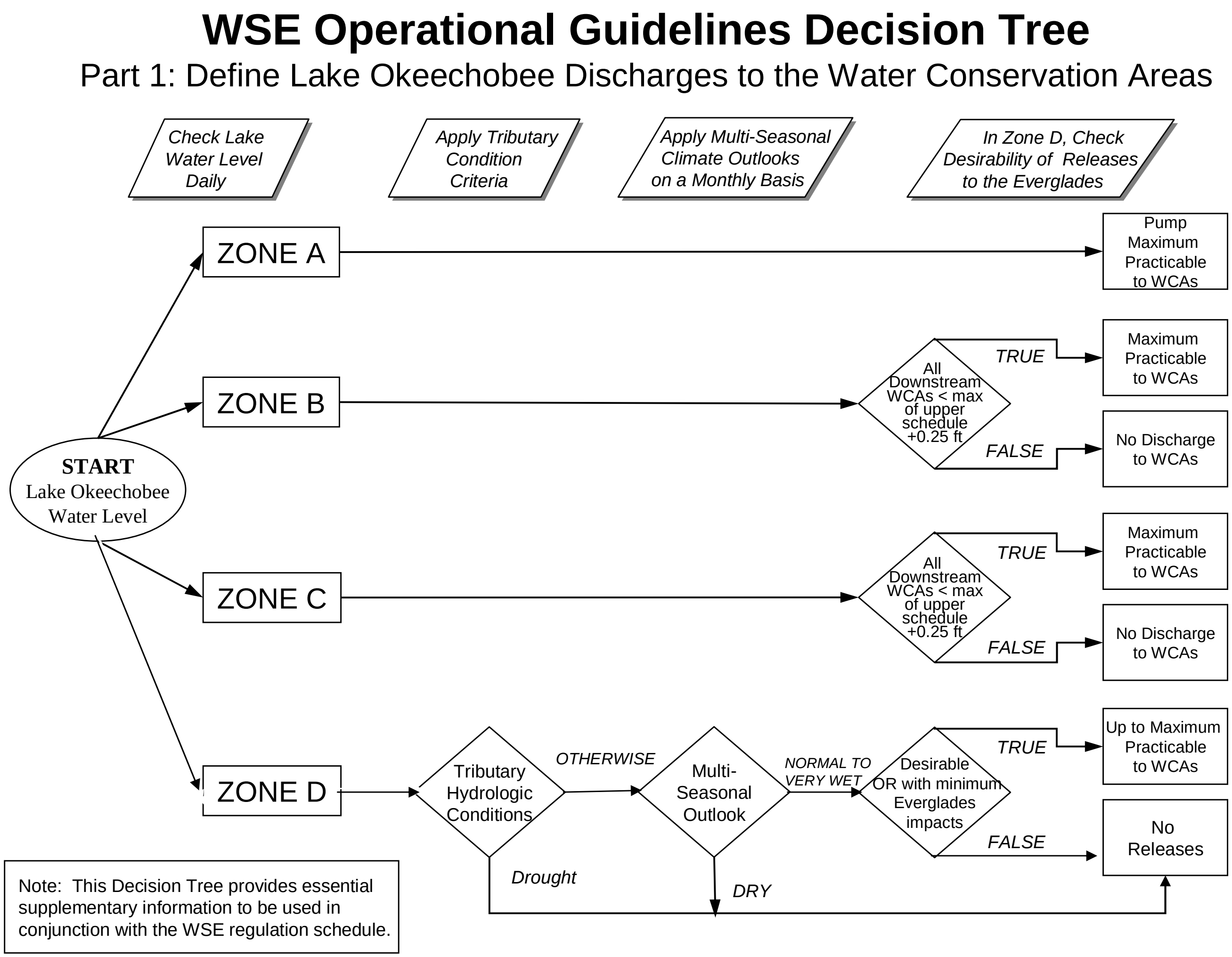


FIGURE 3: DECISION TREE, PART 1 FOR ALTERNATIVE 1BS2-A17.25, ALTERNATIVE 1BS2-M, AND ALTERNATIVE 4-A17.25

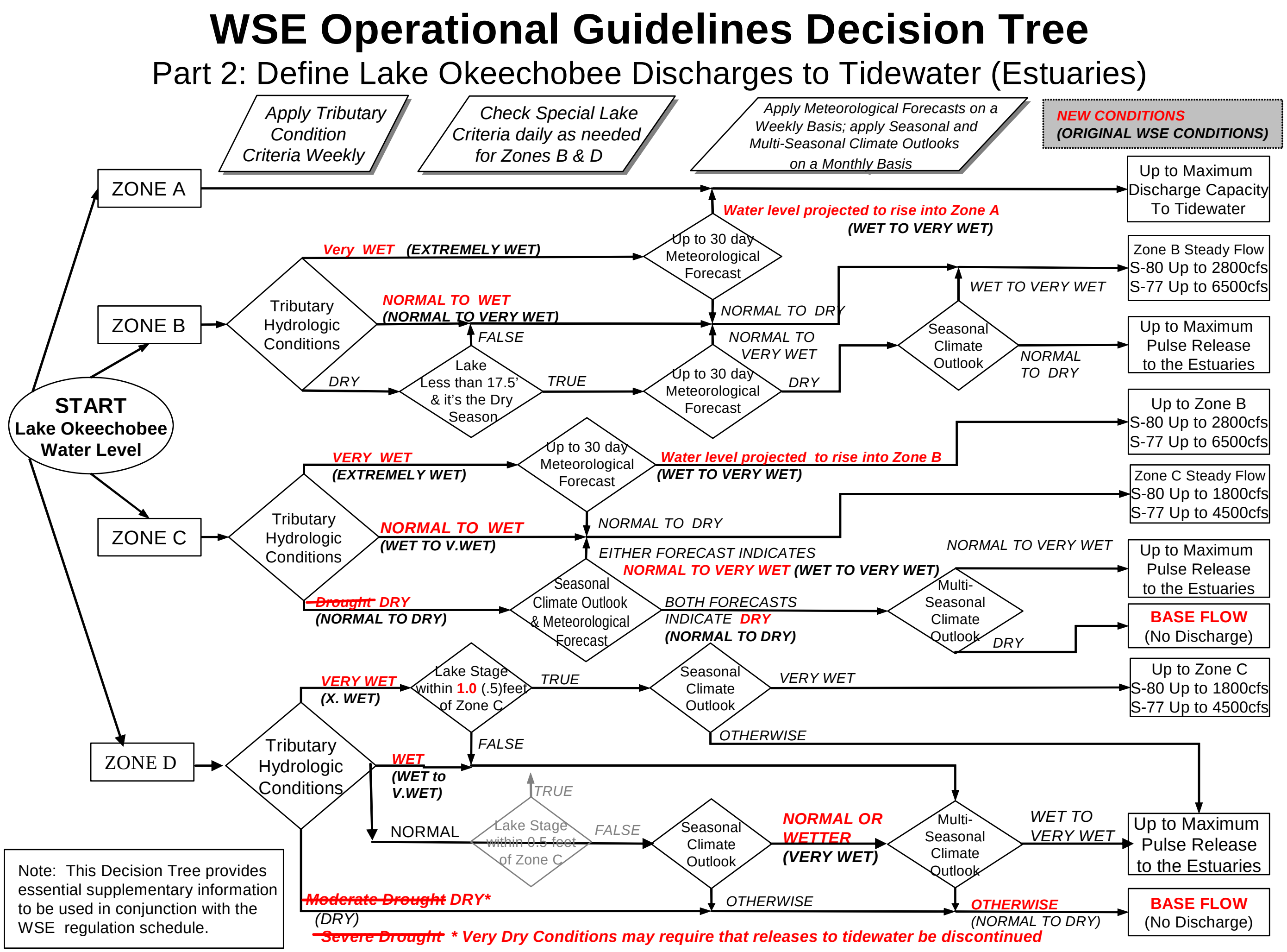


FIGURE 4: DECISION TREE, PART 2 FOR ALTERNATIVE 1BS2-A17.25, ALTERNATIVE 1BS2-M, AND ALTERNATIVE 4-A17.25

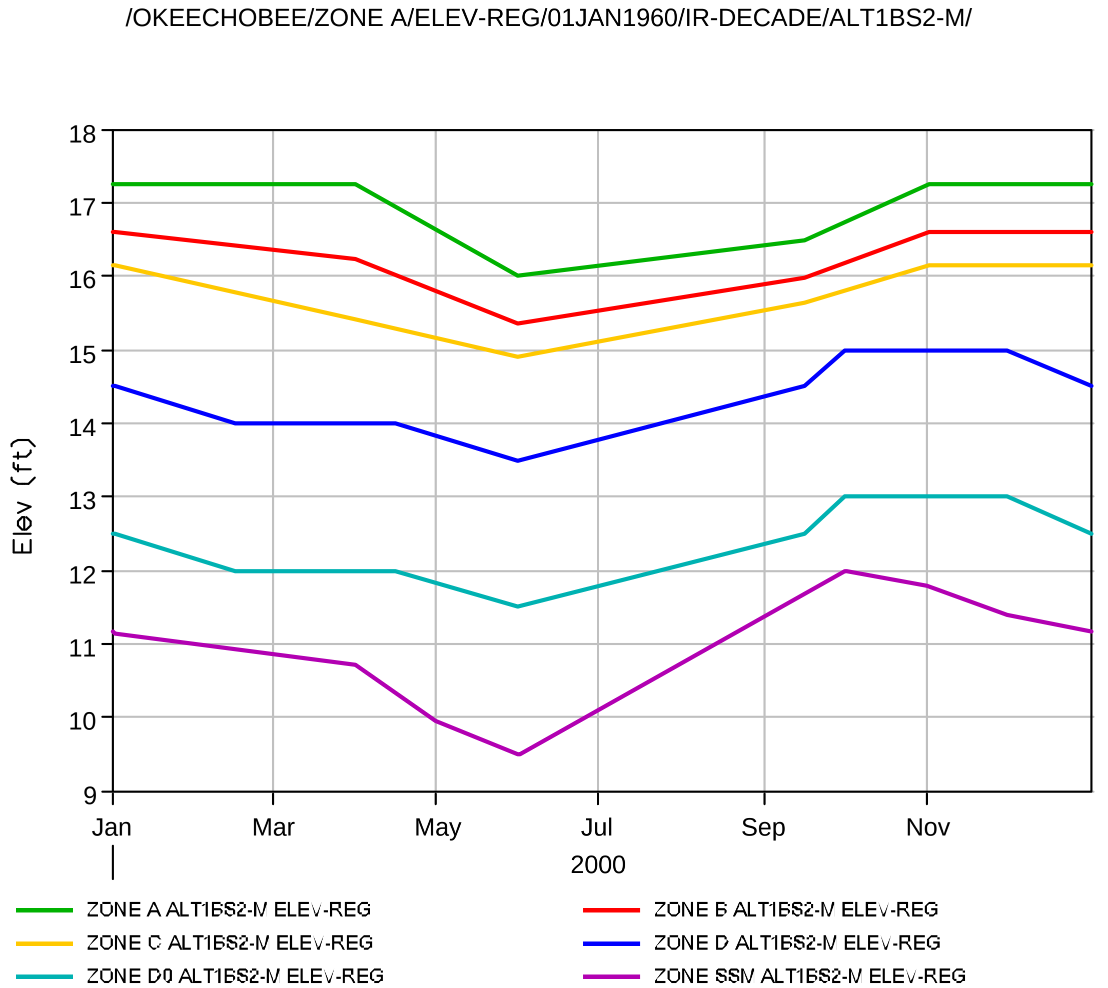


FIGURE 5: REGULATION SCHEDULE FOR ALTERNATIVE 1BS2-M

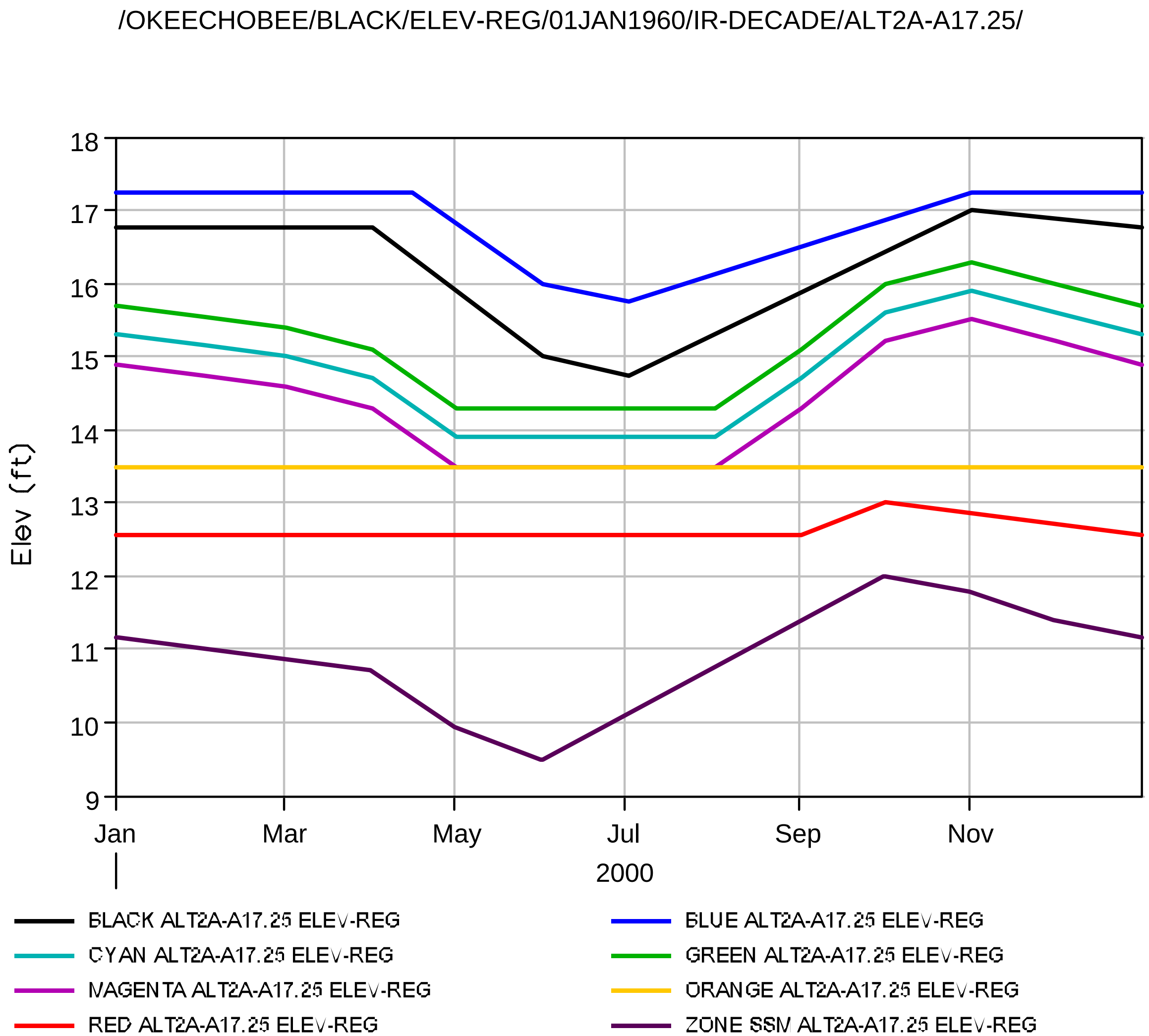


FIGURE 6: REGULATION SCHEDULE FOR ALTERNATIVE 2A-A17.25

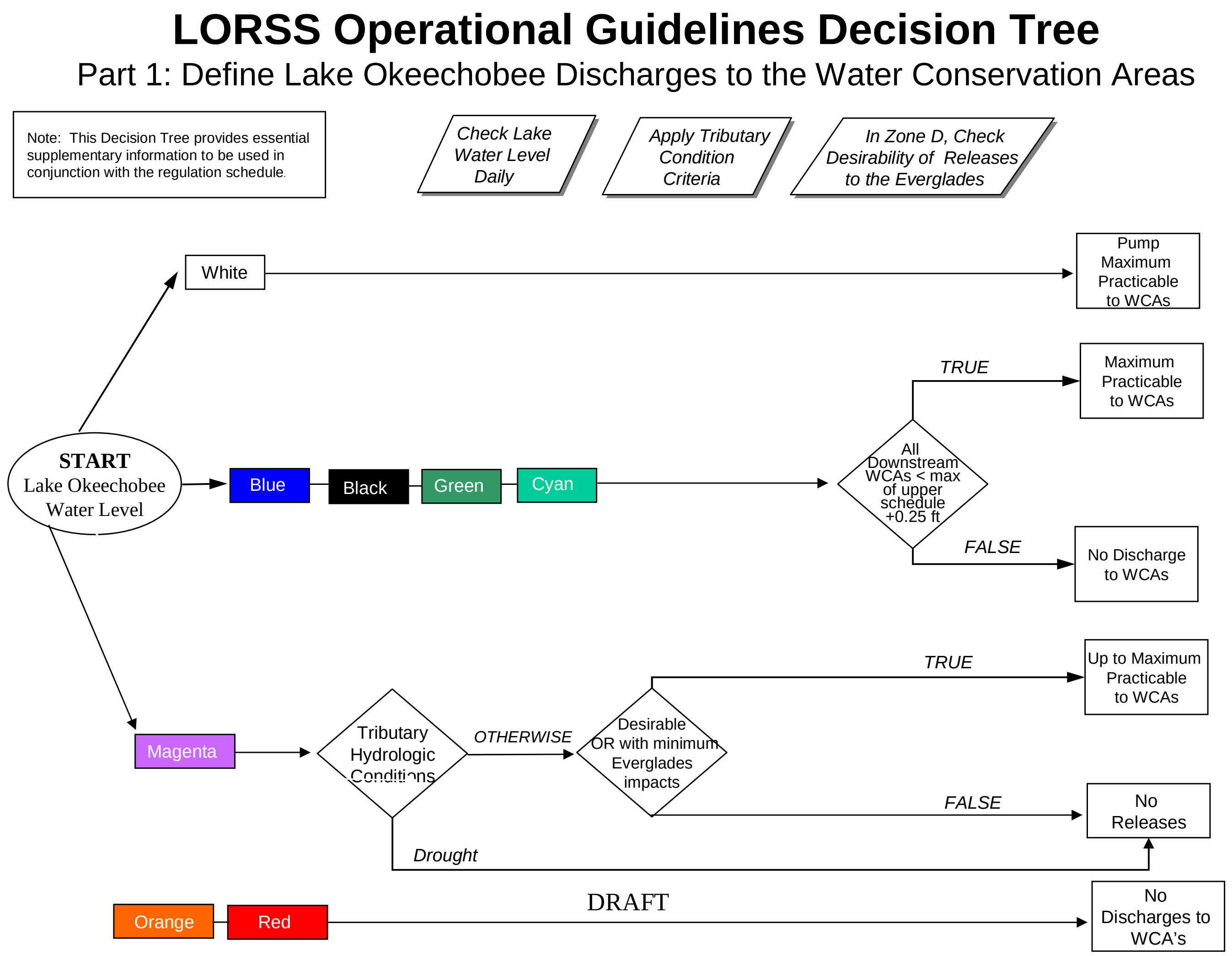


FIGURE 7: DECISION TREE, PART 1 FOR ALTERNATIVE 2A-B AND ALTERNATIVE 2A-M

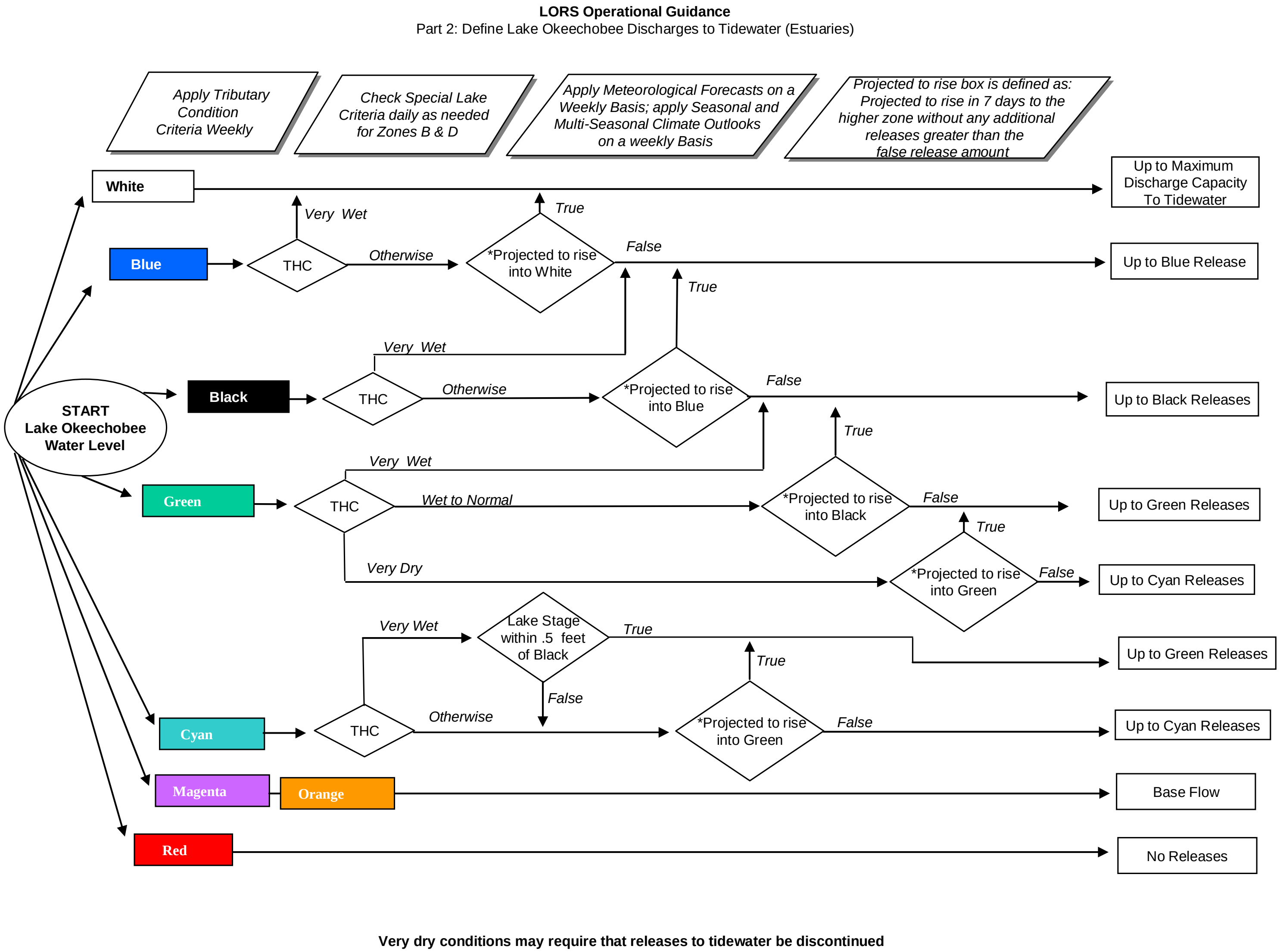


FIGURE 8: DECISION TREE, PART 2 FOR ALTERNATIVE 2A-B AND ALTERNATIVE 2A-M

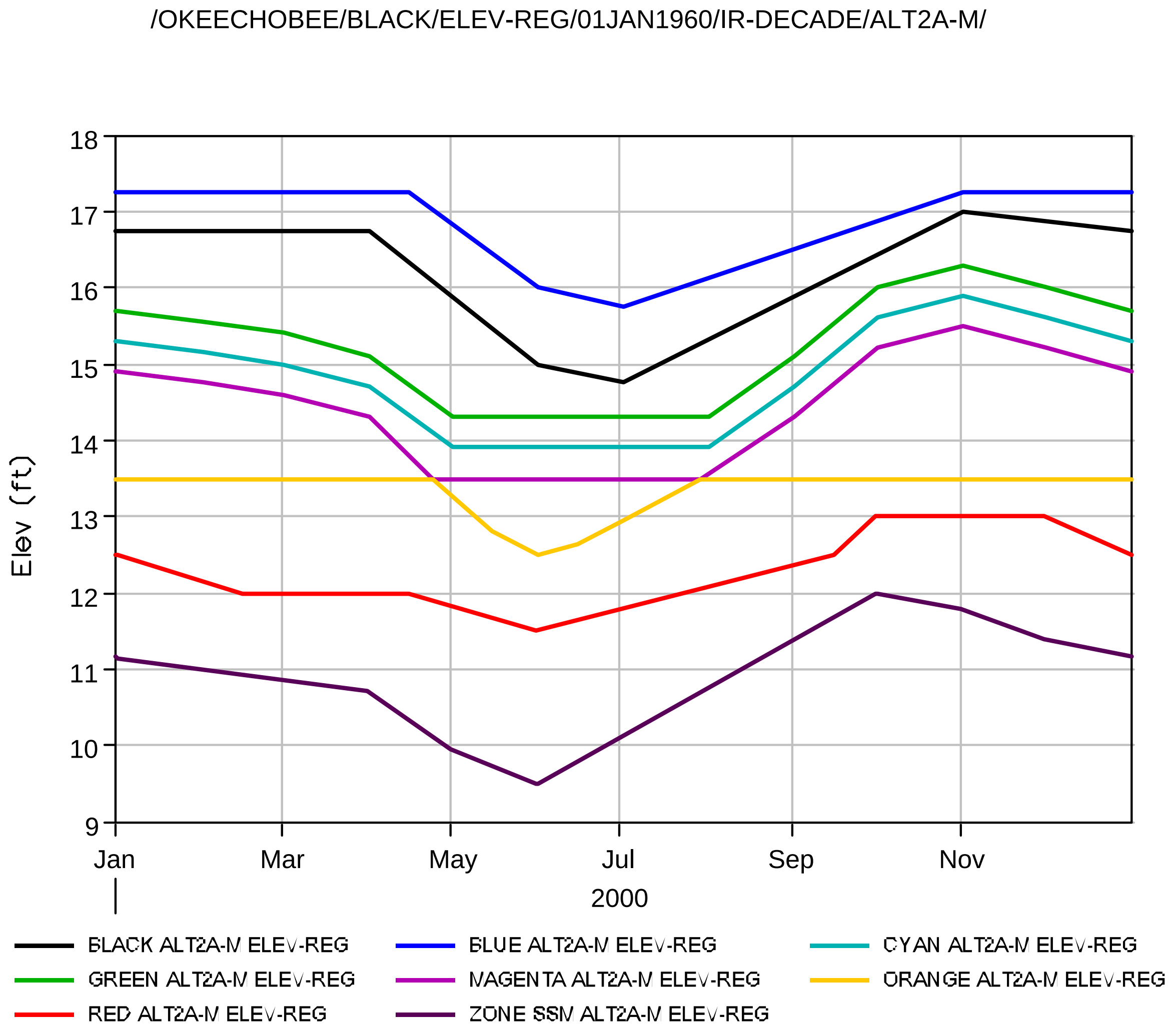
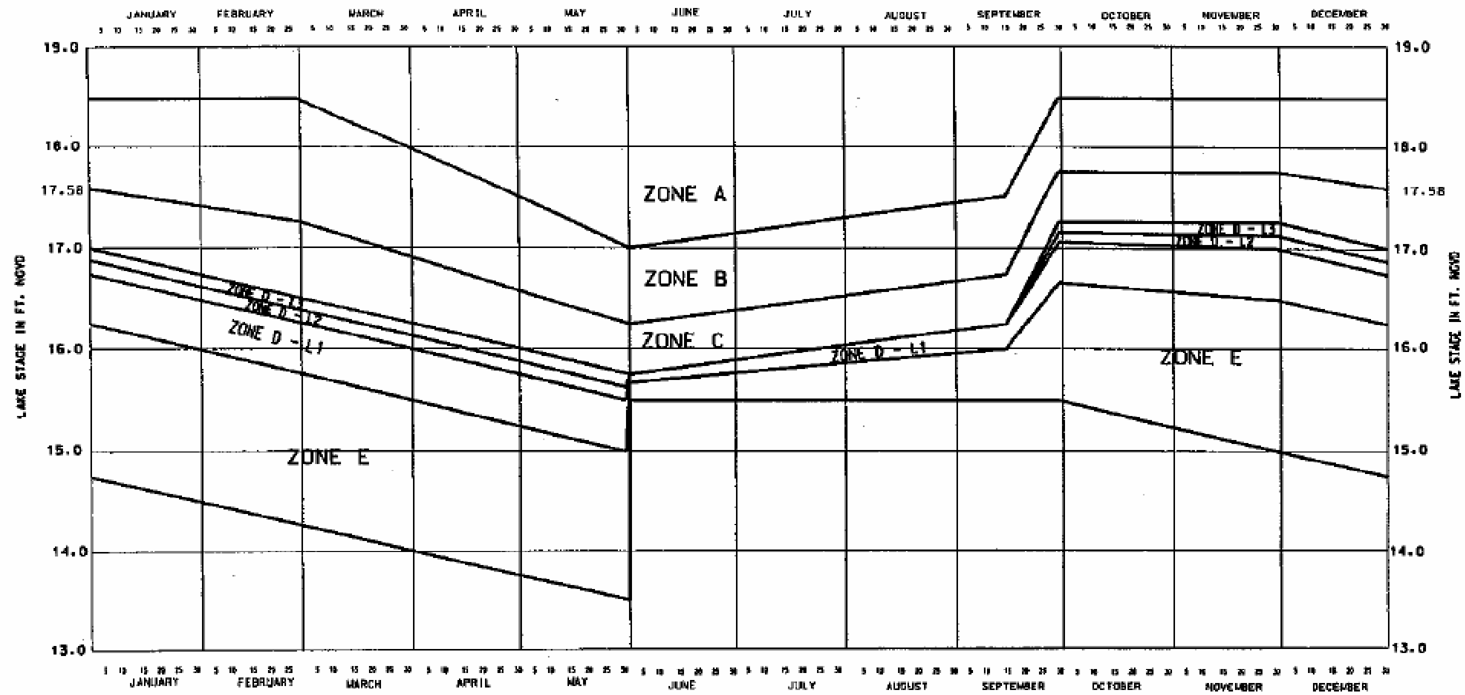


FIGURE 9: REGULATION SCHEDULE FOR ALTERNATIVE 2A-M



LAKE OKEECHOBEE RELEASES

ZONE	AGRICULTURAL CANALS (2)	CALOOSAHATCHEE RIVER (2)	ST. LUCIE CANAL
A	Maximum Practicable Releases to Water Convervation Areas	Up to Maximum Capacity at S-77	Up to Maximum Capacity at S-80
B		6500 CFS	3500 CFS (3)
C		4500 CFS	2500 CFS (3)
D Level 3 Level 2 Level 1		10-day Pulse with a Mean Discharge of: Level 3 = 3000 CFS Level 2 = 2300 CFS Level 1 = 1600 CFS	10-day Pulse with a Mean Discharge of: Level 3 = 1170 CFS Level 2 = 900 CFS Level 1 = 730 CFS
E		No Releases	No Releases

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.
(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.
(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
PROPOSED REGULATION SCHEDULE

LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

R22AZE

Figure 5.2.2-1

FIGURE 10: REGULATION SCHEDULE FOR RUN22AZE

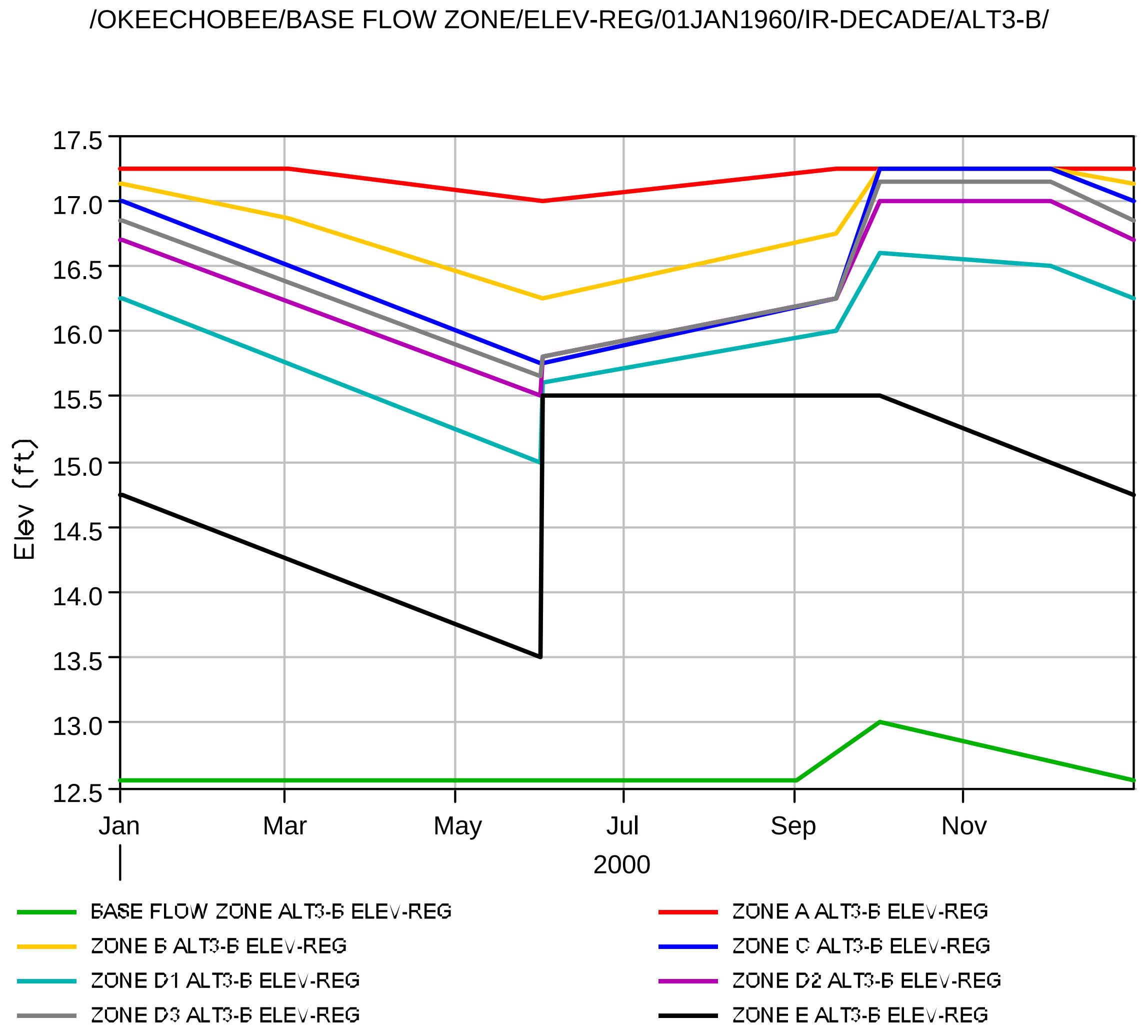


FIGURE 11: REGULATION SCHEDULE FOR ALTERNATIVE 3-B

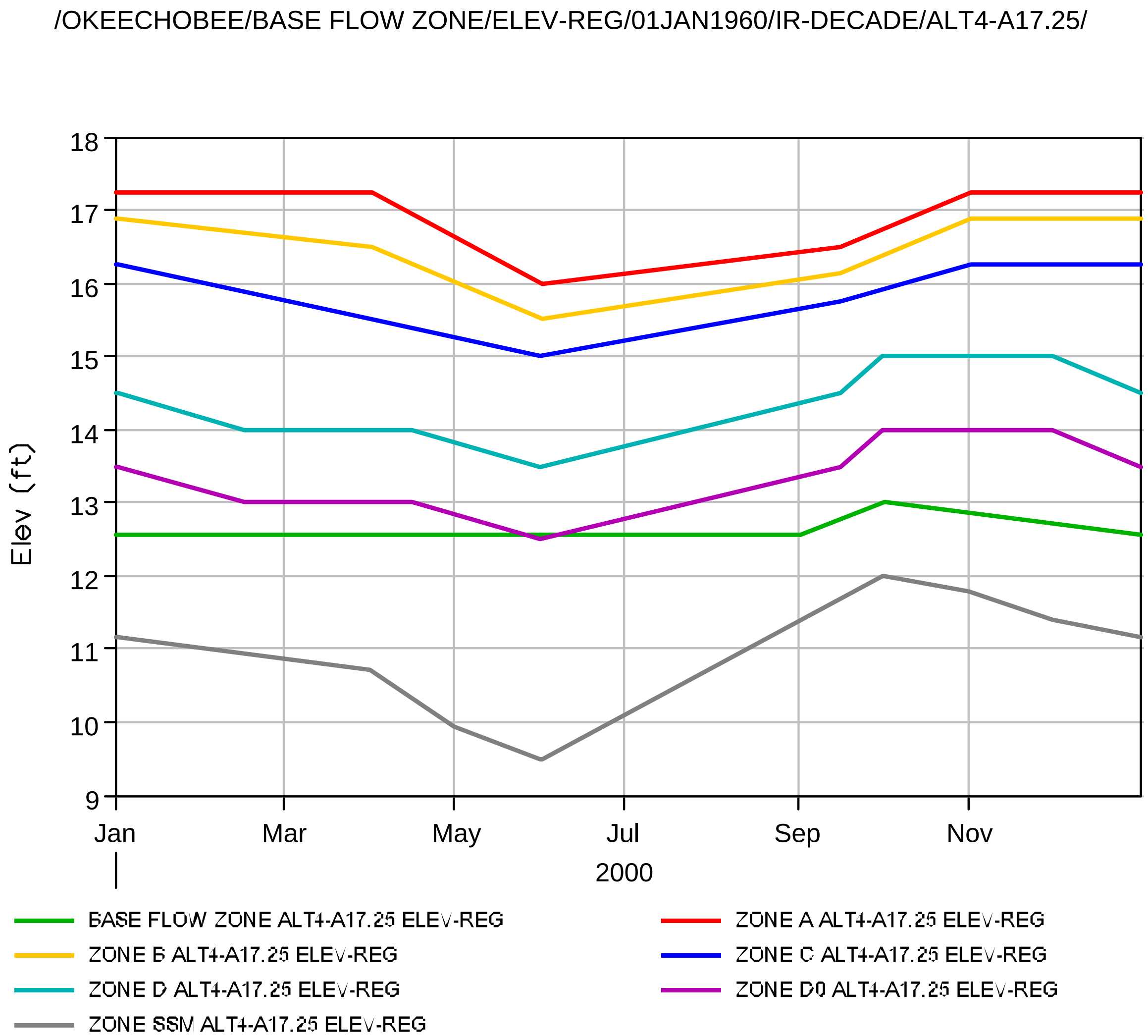


FIGURE 12: REGULATION SCHEDULE FOR ALTERNATIVE 4-A17.25

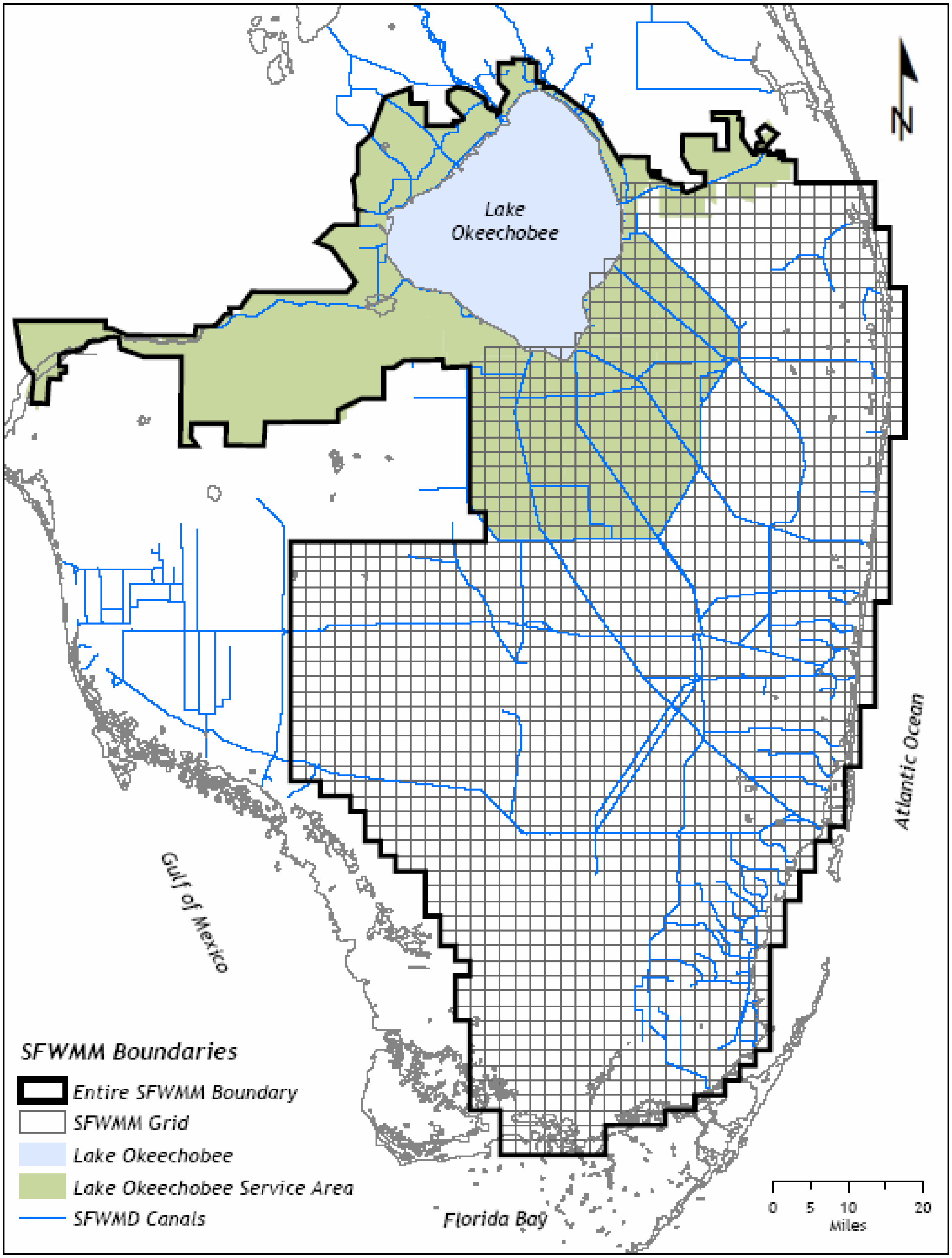


FIGURE 13: SOUTH FLORIDA WATER MANAGEMENT MODEL BOUNDARIES

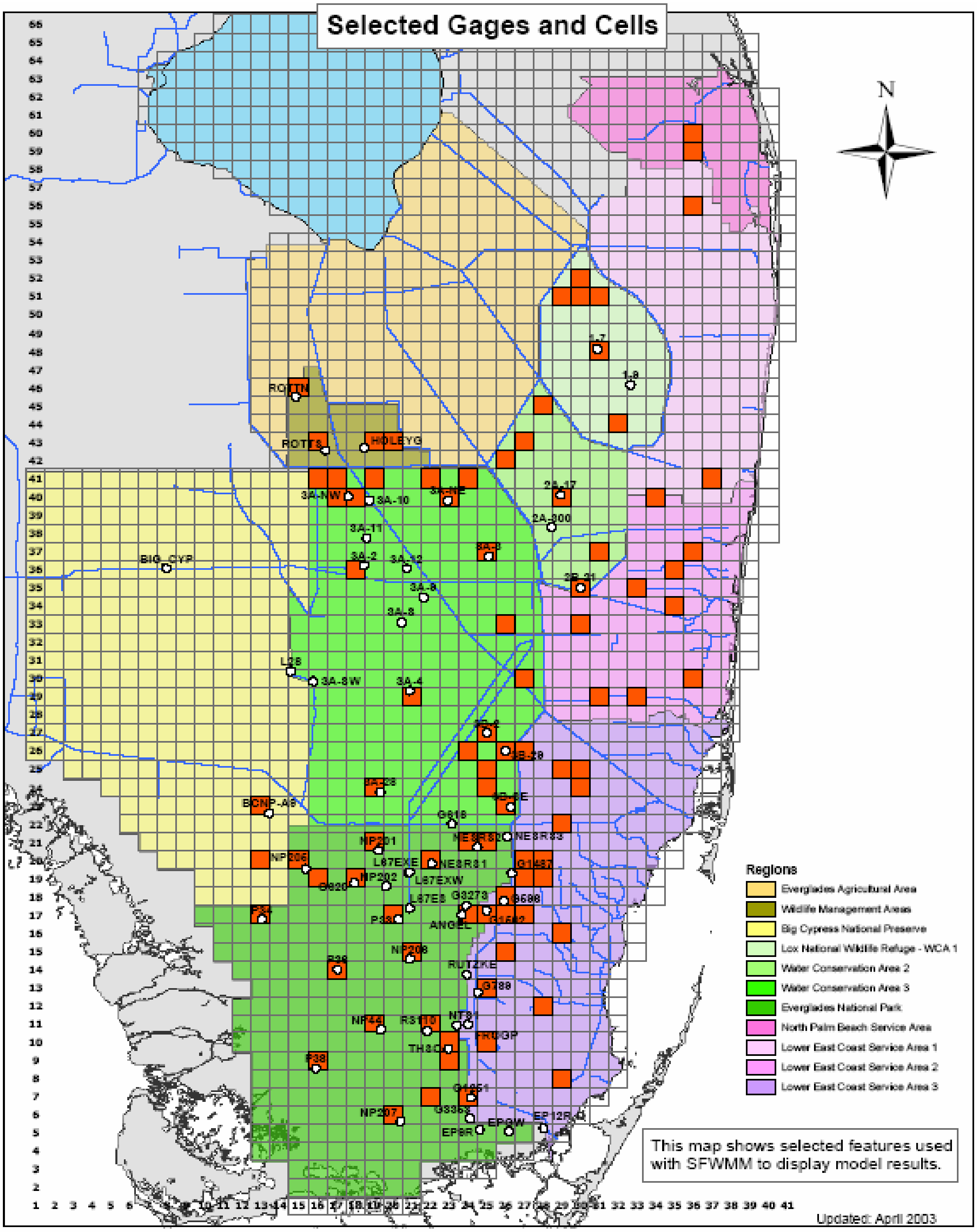


FIGURE 14: GAGE AND MONITORING POINT LOCATIONS REPORTED BY THE SFWMM

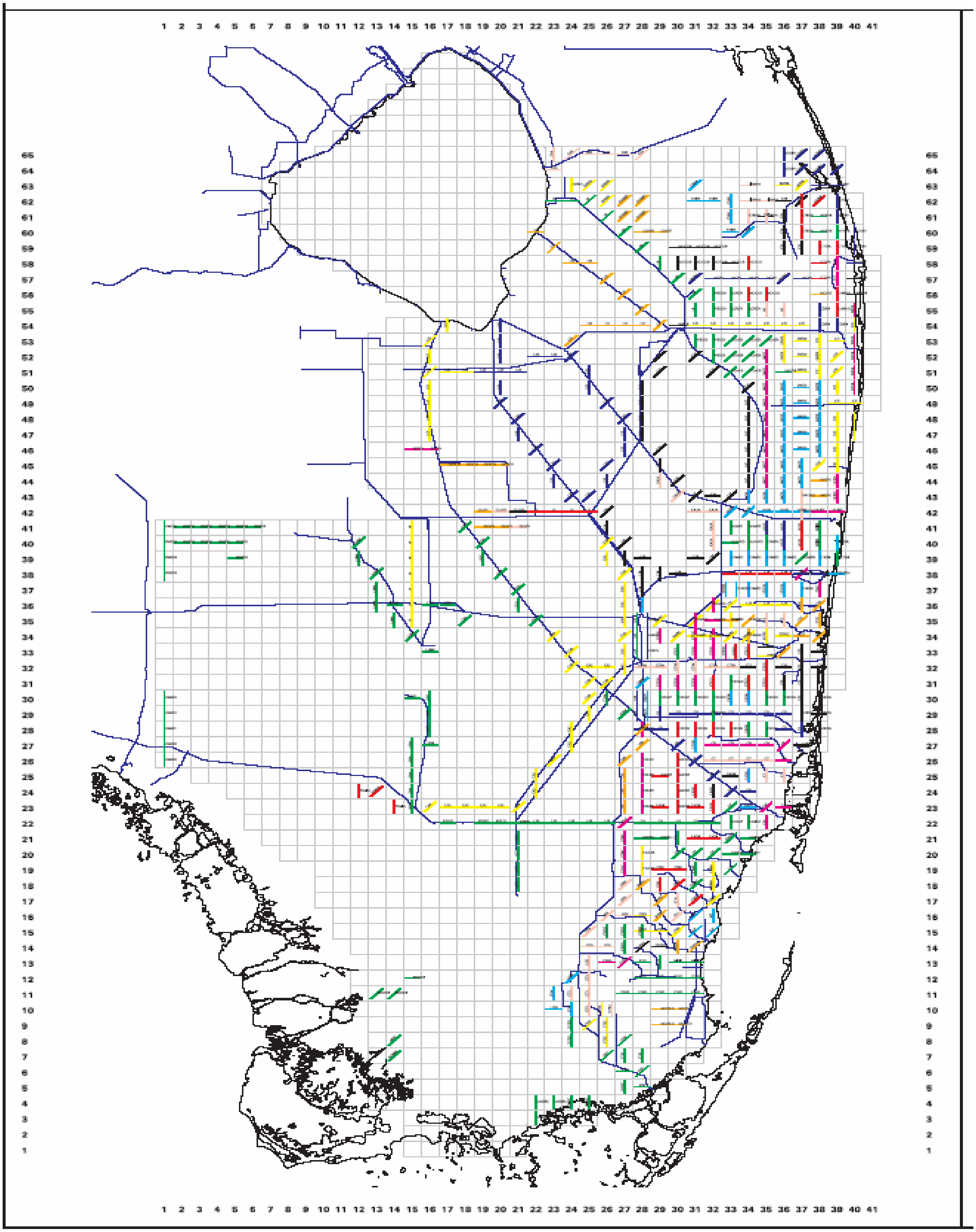


FIGURE 15: SFWMM CANAL NETWORK (VERSION 5.0)

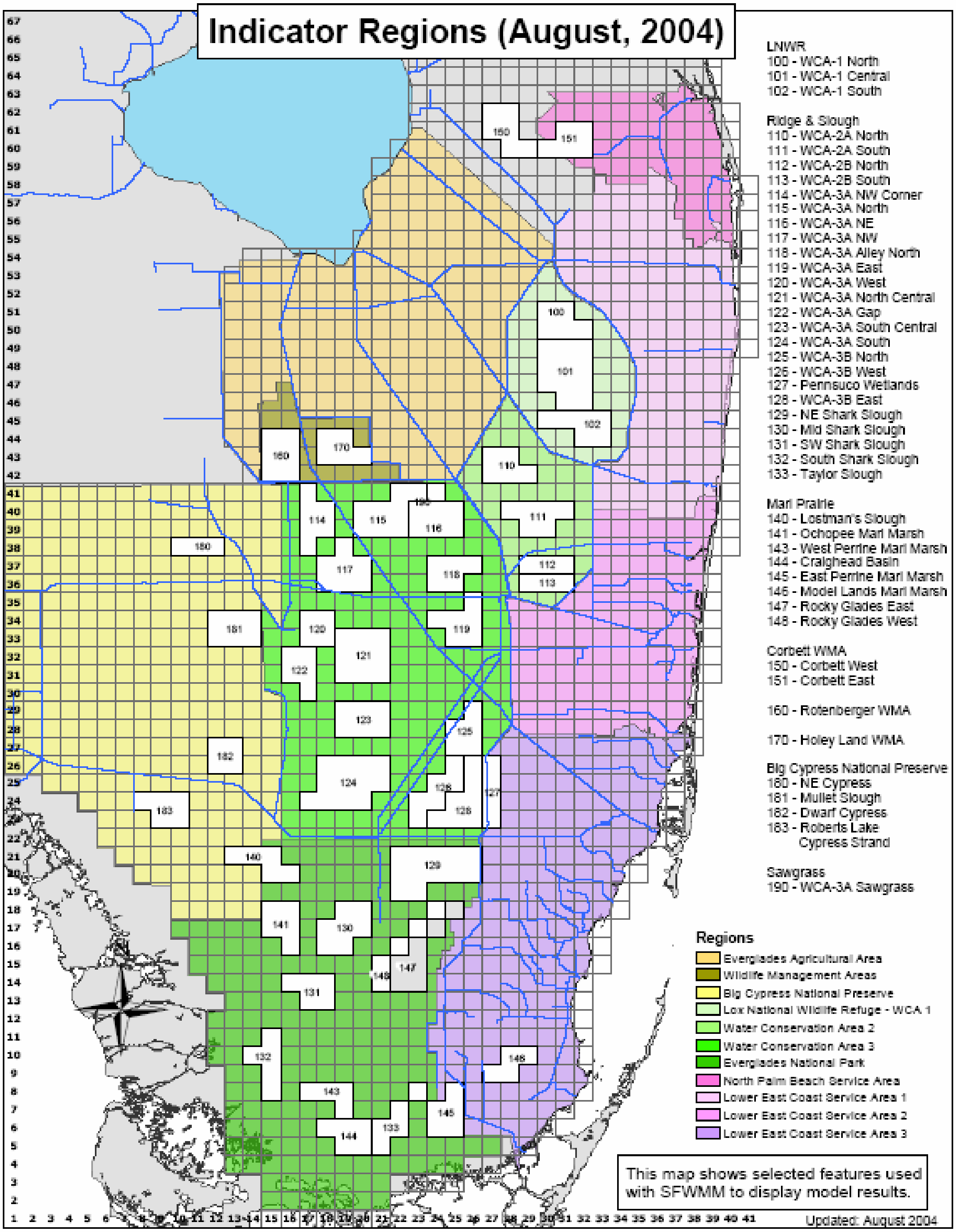


FIGURE 16: SFWMM INDICATOR REGIONS (VERSION 5.0)

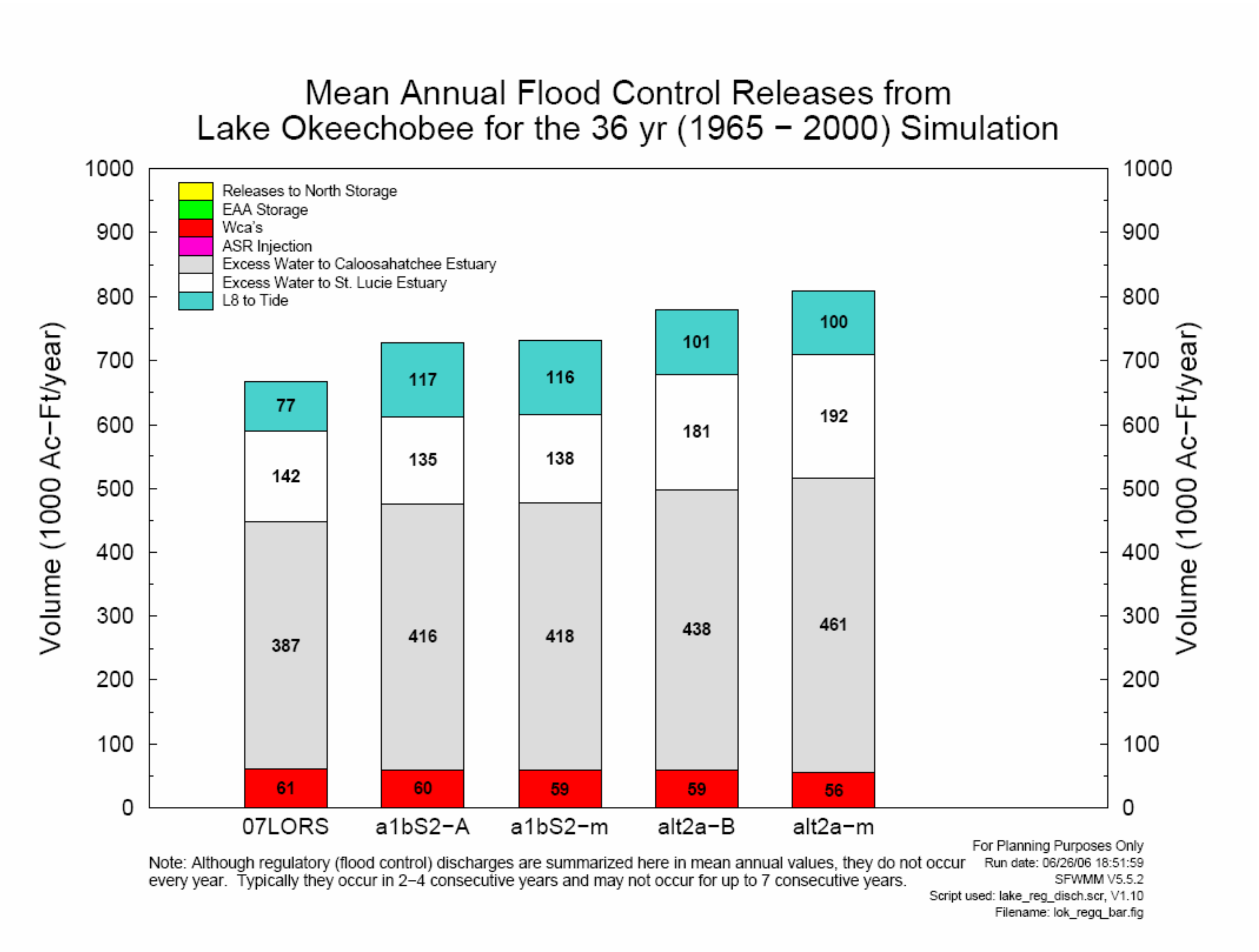


FIGURE 17: MEAN ANNUAL FLOOD CONTROL RELEASES FROM LAKE OKEECHOBEE (1)

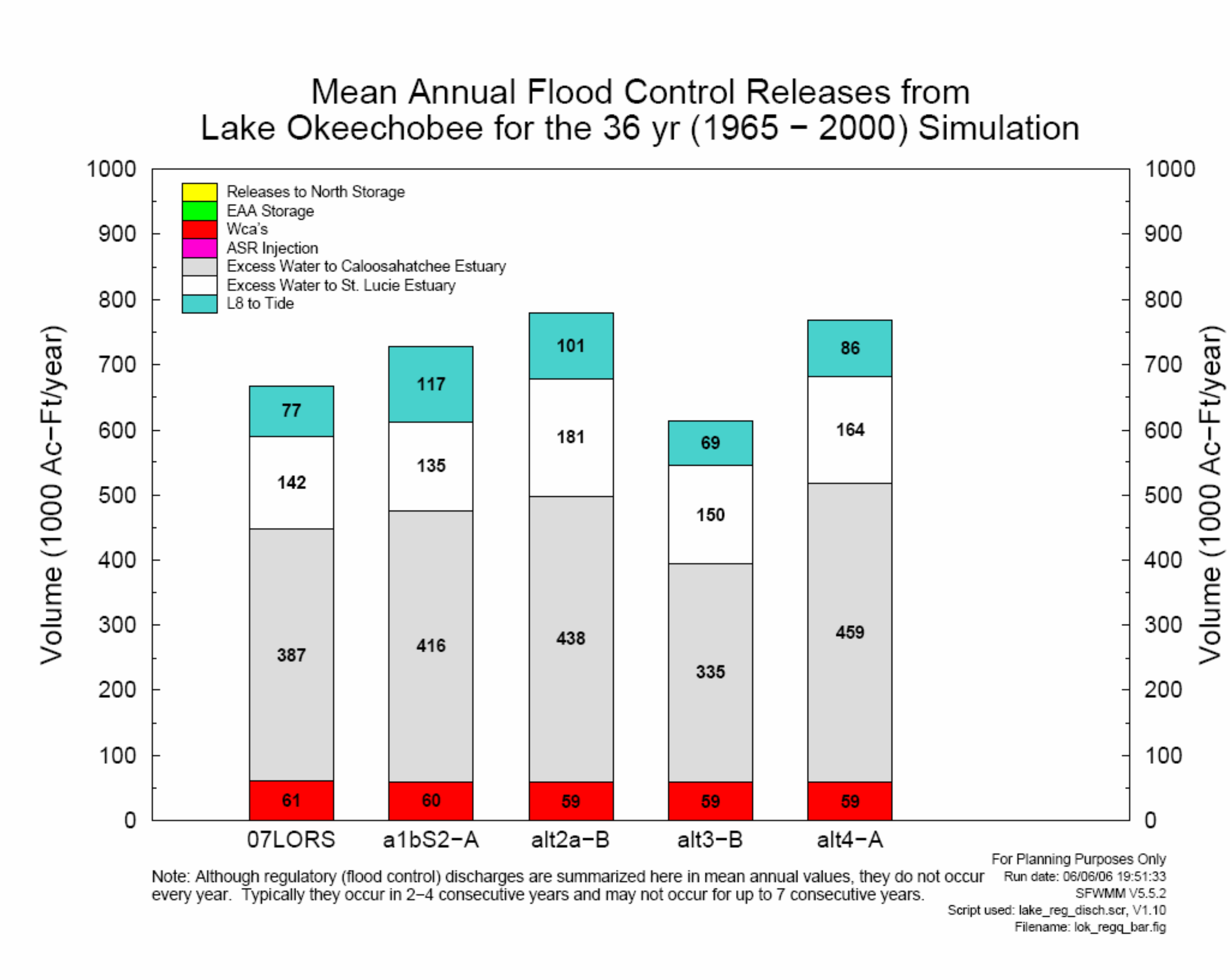


FIGURE 18: MEAN ANNUAL FLOOD CONTROL RELEASES RROM LAKE OKEECHOBEE (2)

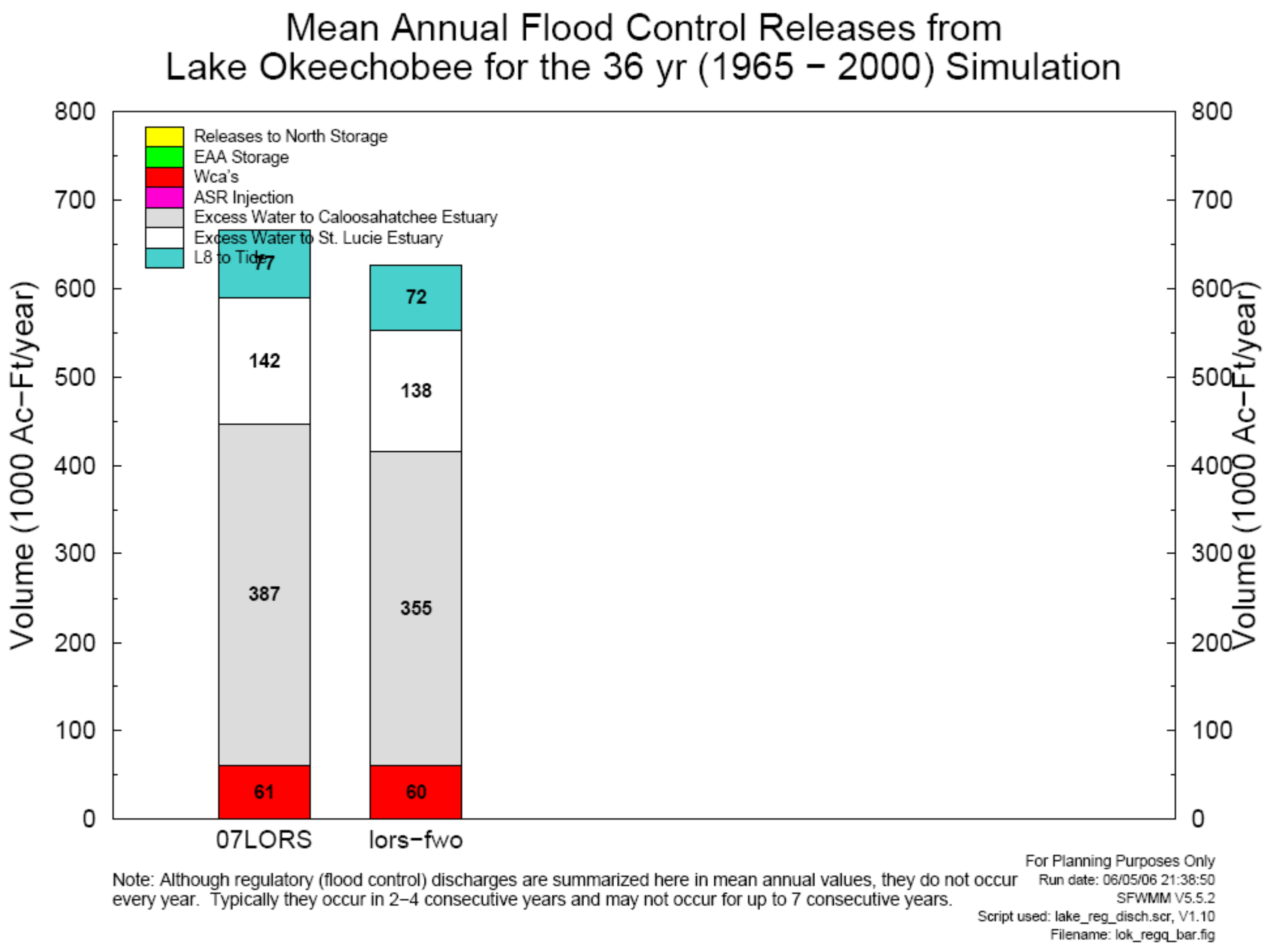


FIGURE 19: MEAN ANNUAL FLOOD CONTROL RELEASES RROM LAKE OKEECHOBEE (3)

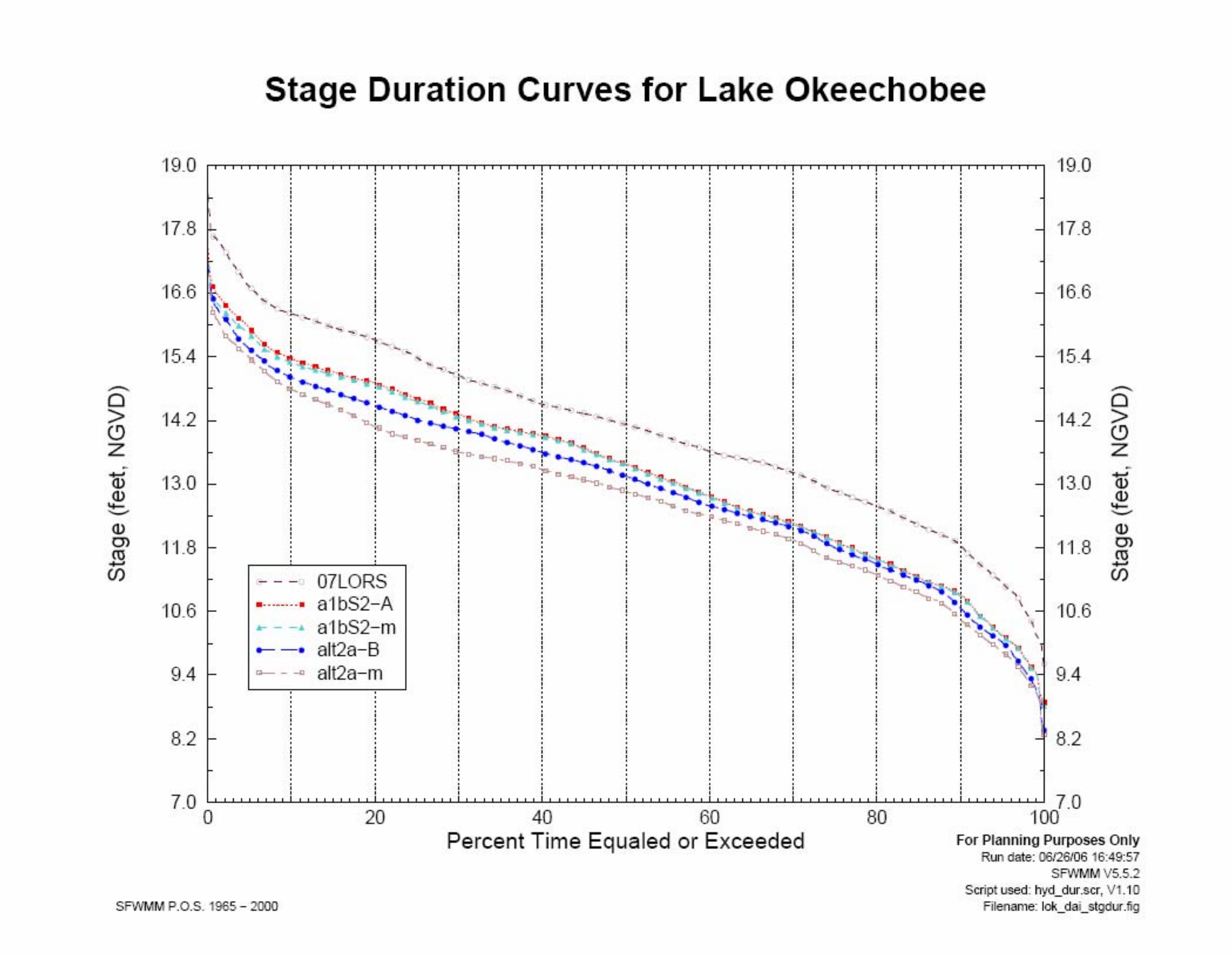


FIGURE 20: LAKE OKEECHOBEE STAGE DURATION CURVES (1)

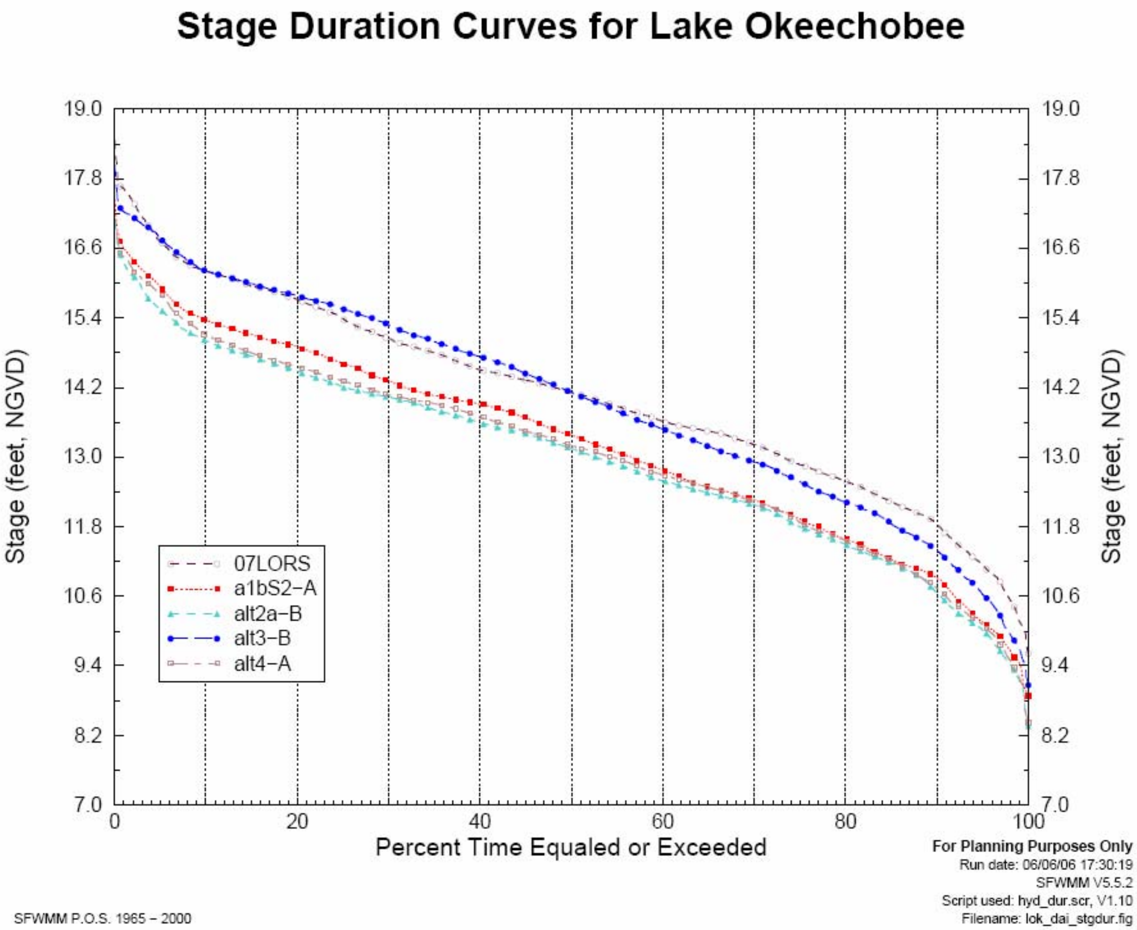


FIGURE 21: LAKE OKEECHOBEE STAGE DURATION CURVES (2)

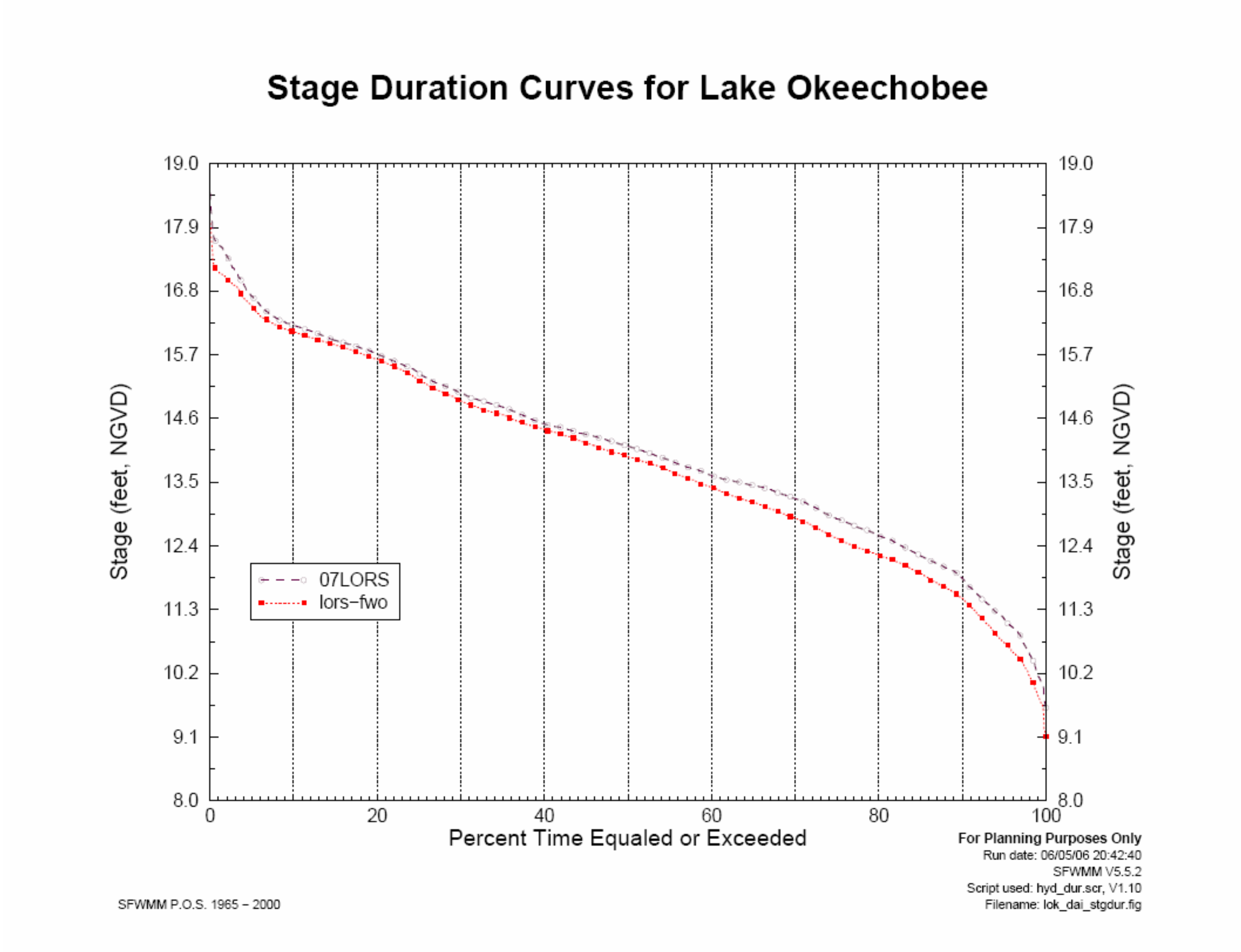


FIGURE 22: LAKE OKEECHOBEE STAGE DURATION CURVES (3)

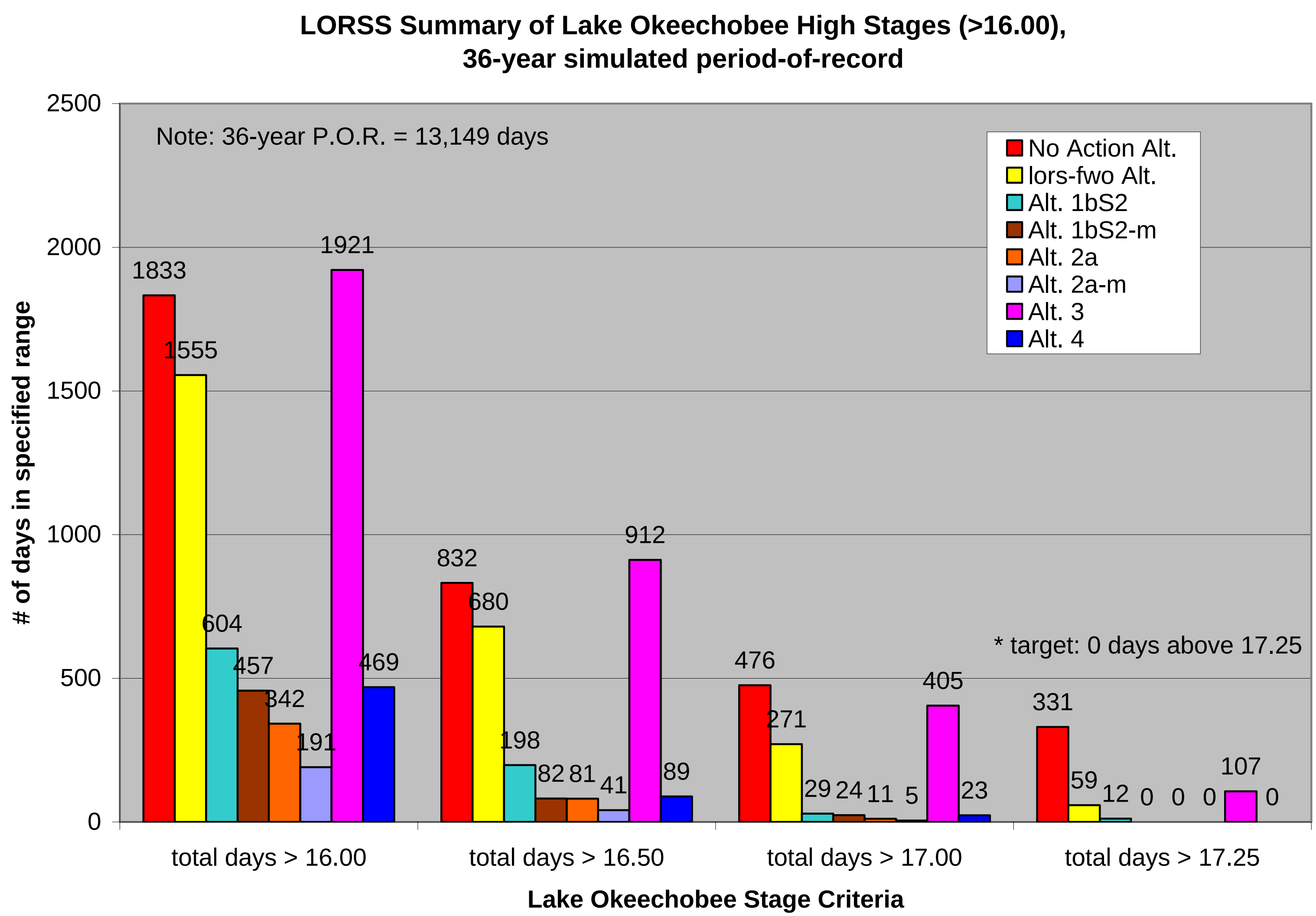


FIGURE 23: OCCURRENCE FREQUENCY OF LAKE OKEECHOBEE HIGH STAGES

Month

Stage	J	F	M	A	M	J	J	A	S	O	N	D	
19	3.5	4	4.5	5	6	6.5	6.5	6	5	4	3.5	3.5	
18.5	3	3.5	4	4.5	5.5	6	6	5.5	4.5	3.5	3	3	
18	2.5	3	3.5	4	5	5.5	5.5	5	4	3	2.5	2.5	
17.5	2	2.5	3	3.5	4.5	5	5	4.5	3.5	2.5	2	2	
17	1.5	2	2.5	3	4	4.5	4.5	4	3	2	1.5	1.5	A
16.5	1	1.5	2	2.5	3.5	4	4	3.5	2.5	1.5	1	1	
16	0.5	1	1.5	2	3	3.5	3.5	3	2	1	0.5	0.5	B
15.5	0	0.5	1	1.5	2.5	3	3	2.5	1.5	0.5	0	0	
15	0	0	0.5	1	2	2.5	2.5	2	1	0	0	0	
14.5	0	0	0	0.5	1.5	2	2	1.5	0.5	0	0	0	
14	0.5	0	0	0	1	1.5	1.5	1	0	0	0.5	0.5	
13.5	1	0.5	0	0	0.5	1	2	0.5	0	0	1	1	
13	1.5	1	0.5	0	0	0.5	0.5	0	0	0.5	1.5	1.5	
12.5	2	1.5	1	0.5	0	0	0	0	0	1	2	2	
12	2.5	2	1.5	1	0	0	0	0	0.5	1.5	2.5	2.5	
11.5	3	2.5	2	1.5	0.5	0.5	0.5	0.5	1	2	3	3	
11	3.5	3	2.5	2	1	1	1	1	1.5	2.5	3.5	3.5	C
10.5	4	3.5	3	2.5	1.5	1.5	1.5	1.5	2	3	4	4	
10	4.5	4	3.5	3	2	2	2	2	2.5	3.5	4.5	4.5	
9.5	5	4.5	4	3.5	2.5	2.5	2.5	2.5	3	4	5	5	
9	5.5	5	4.5	4	3	3	3	3	3.5	4.5	5.5	5.5	
8.5	6	5.5	5	4.5	3.5	3.5	3.5	3.5	4	5	6	6	
8	5.6	6	5.5	5	4	4	4	4	4.5	5.5	5.6	5.6	
7.5	7	6.5	6	5.5	4.5	4.5	4.5	4.5	5	6	7	7	

FIGURE 24: CONCEPTUALIZATION OF LAKE OKEECHOBEE STAGE ENVELOPE PERFORMANCE MEASURE

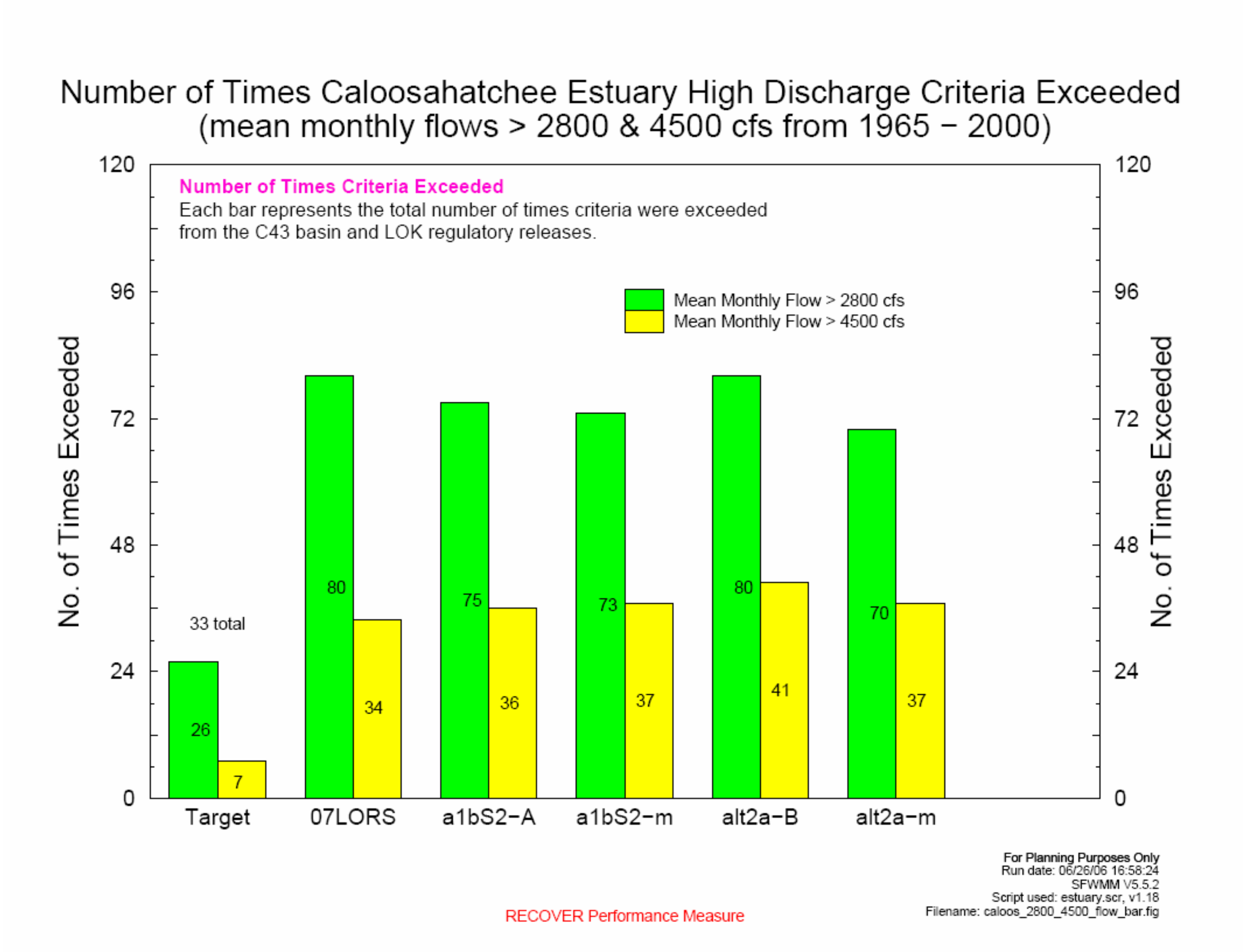


FIGURE 25: CALOOSAHATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

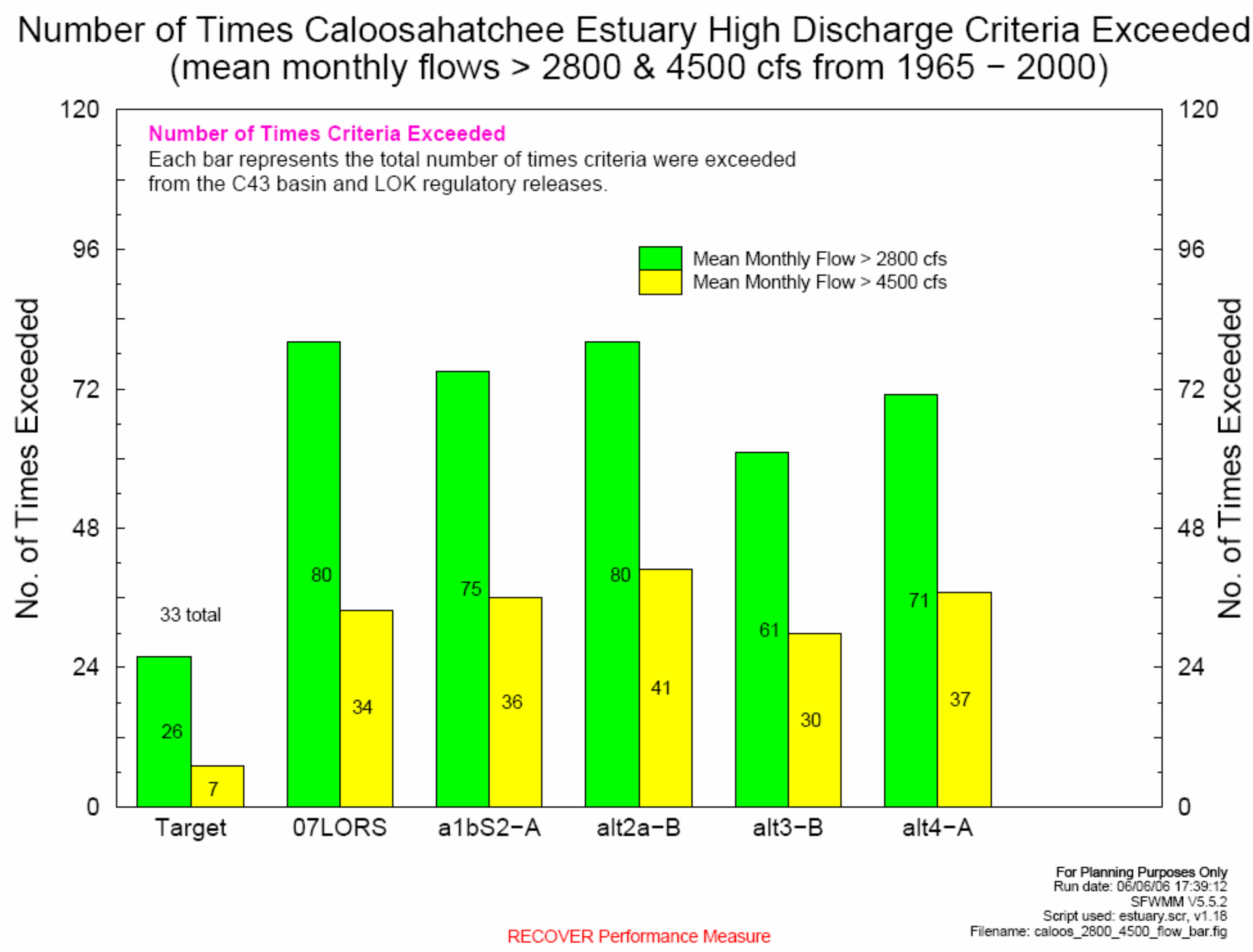


FIGURE 26: CALOOSAHATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

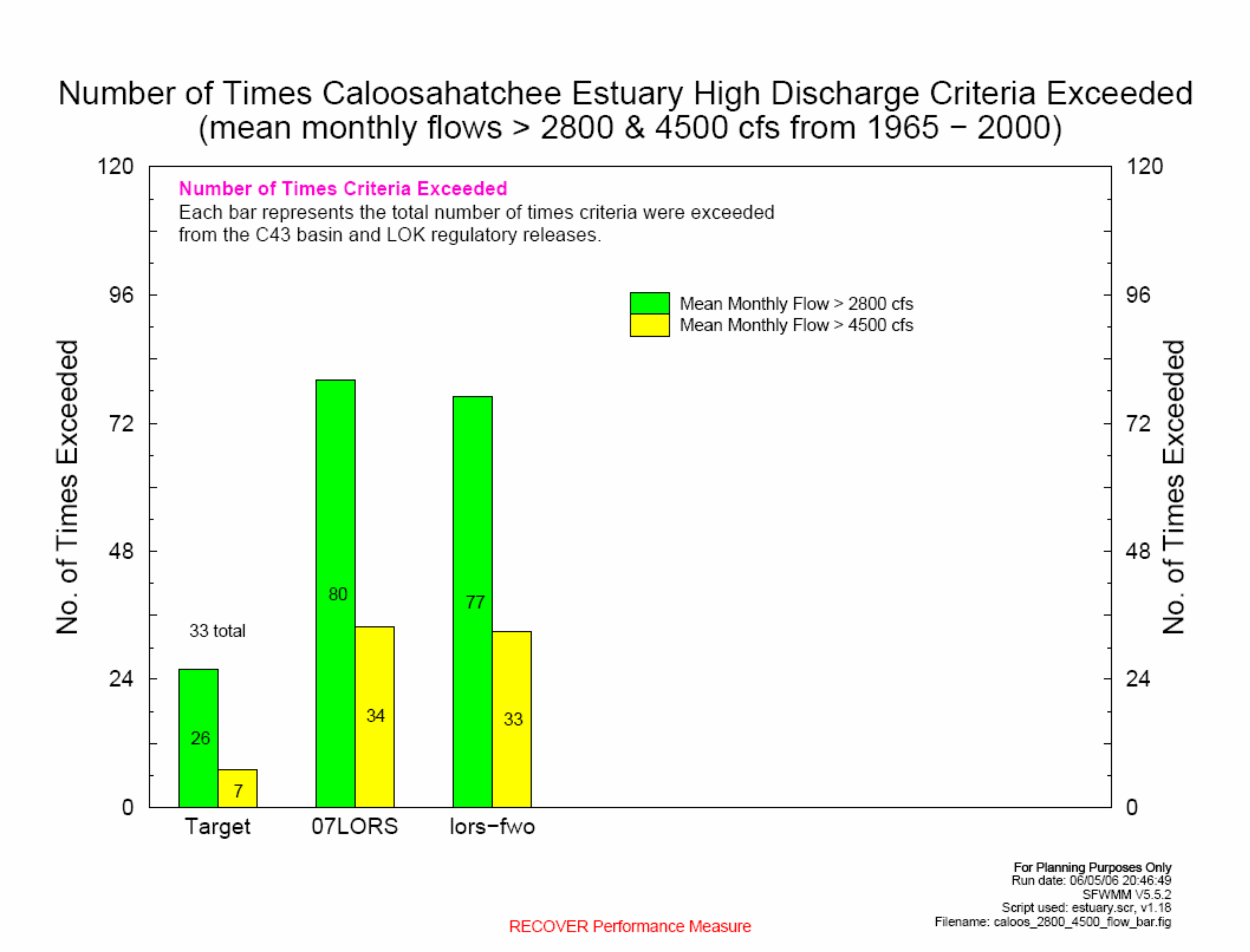


FIGURE 27: CALOOSAHATCHEE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (3)

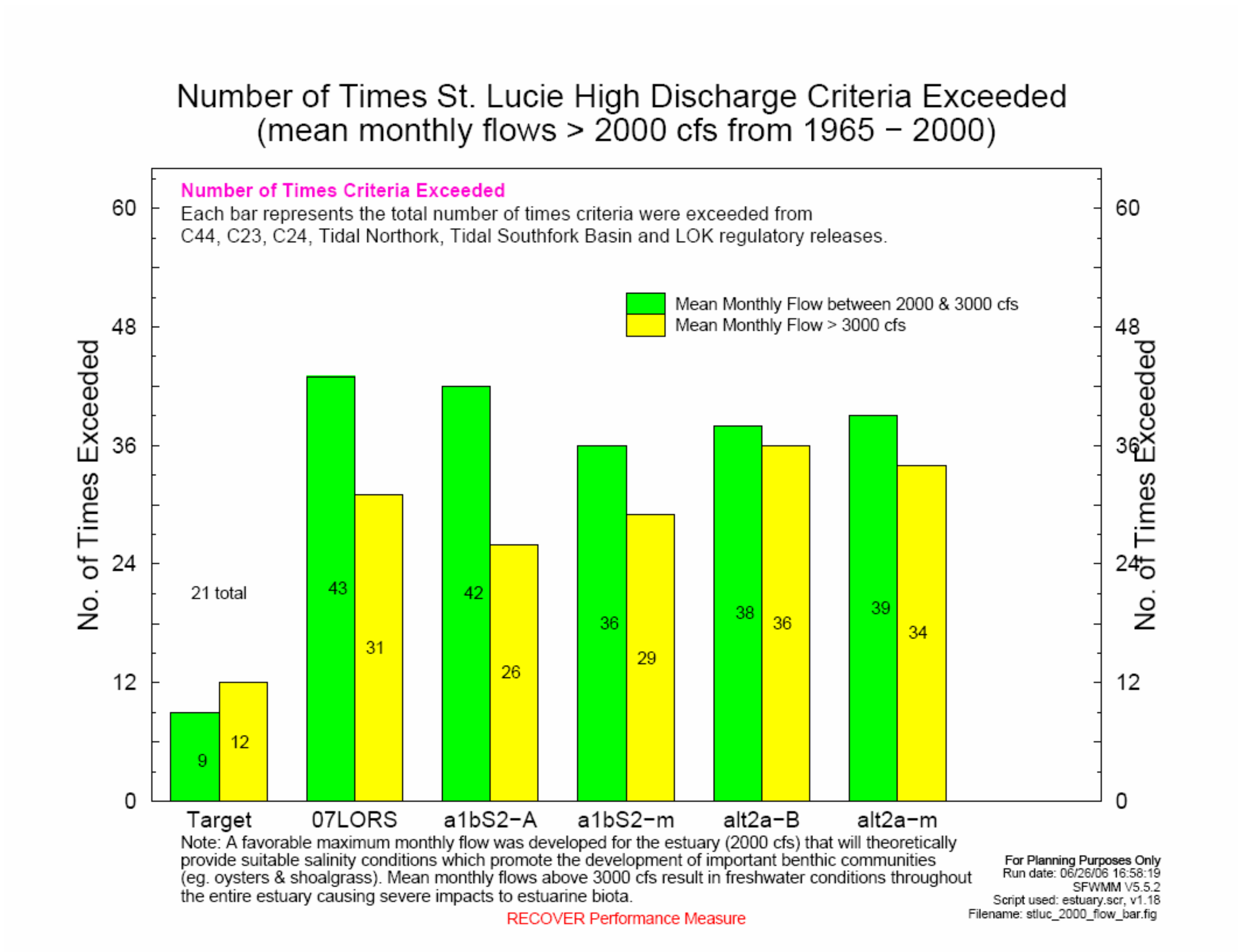


FIGURE 28: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (1)

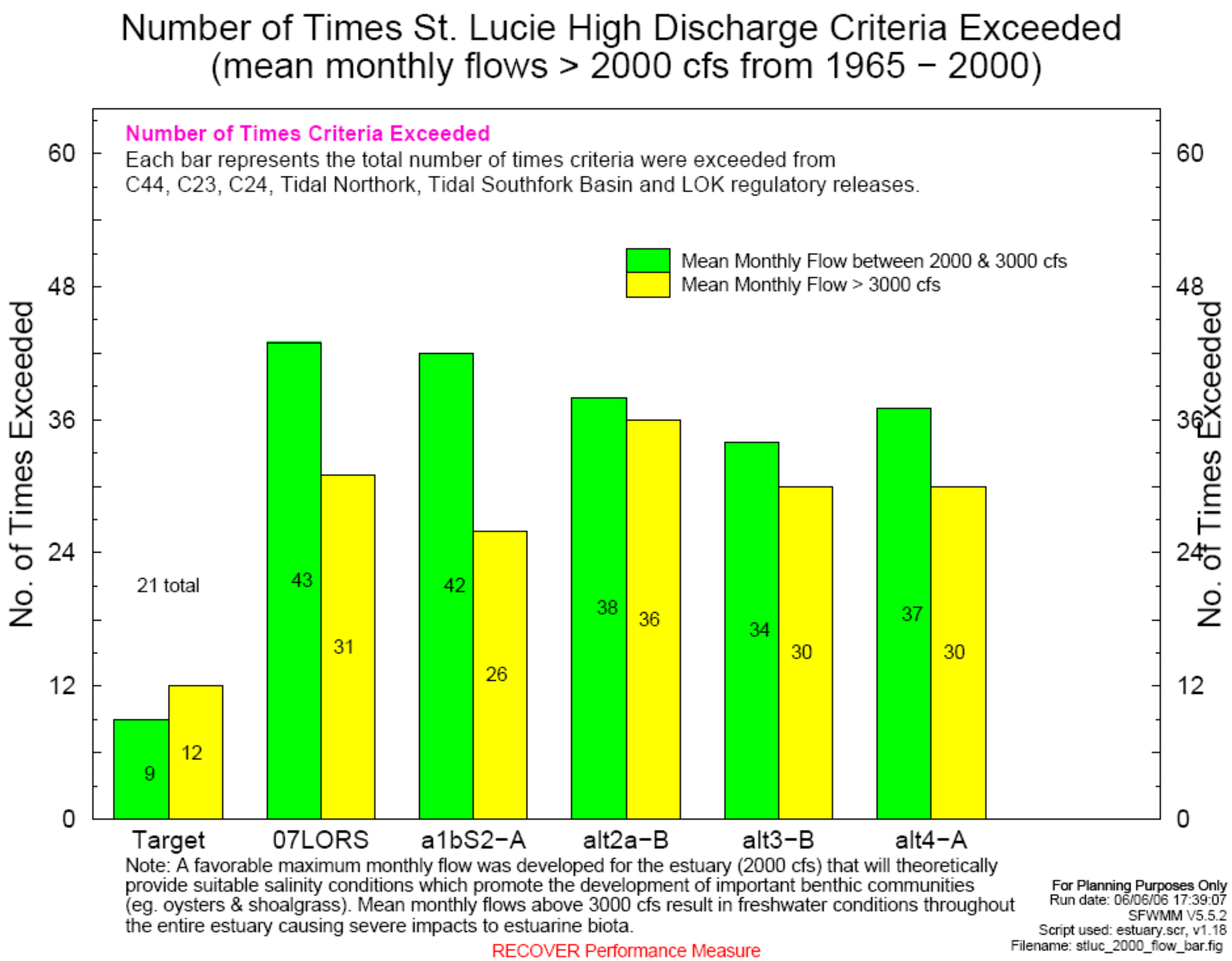


FIGURE 29: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (2)

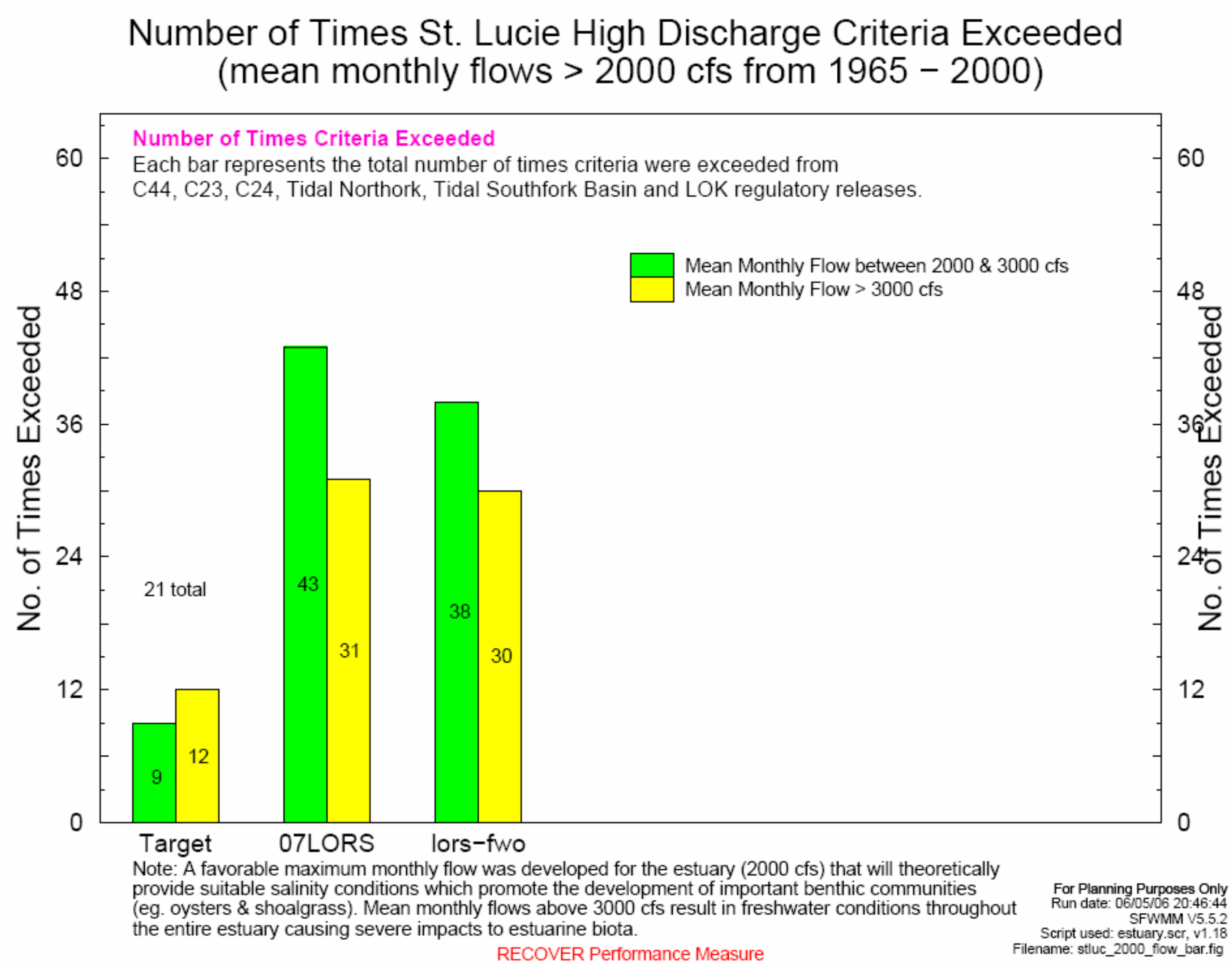


FIGURE 30: ST. LUCIE ESTUARY HIGH DISCHARGE CRITERIA EXCEEDED (3)

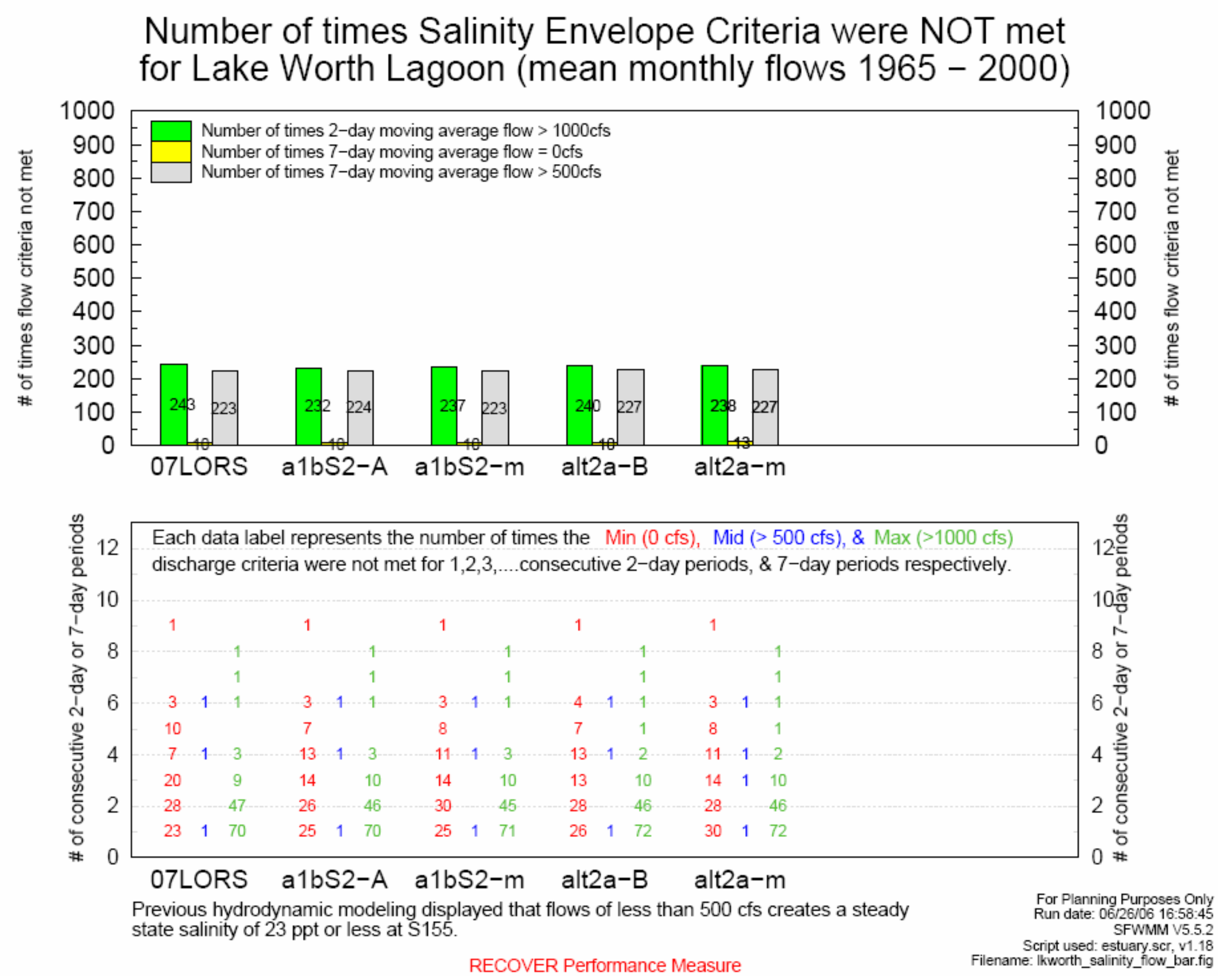


FIGURE 31: LAKE WORTH LAGOON SALINITY ENVELOPE (1)

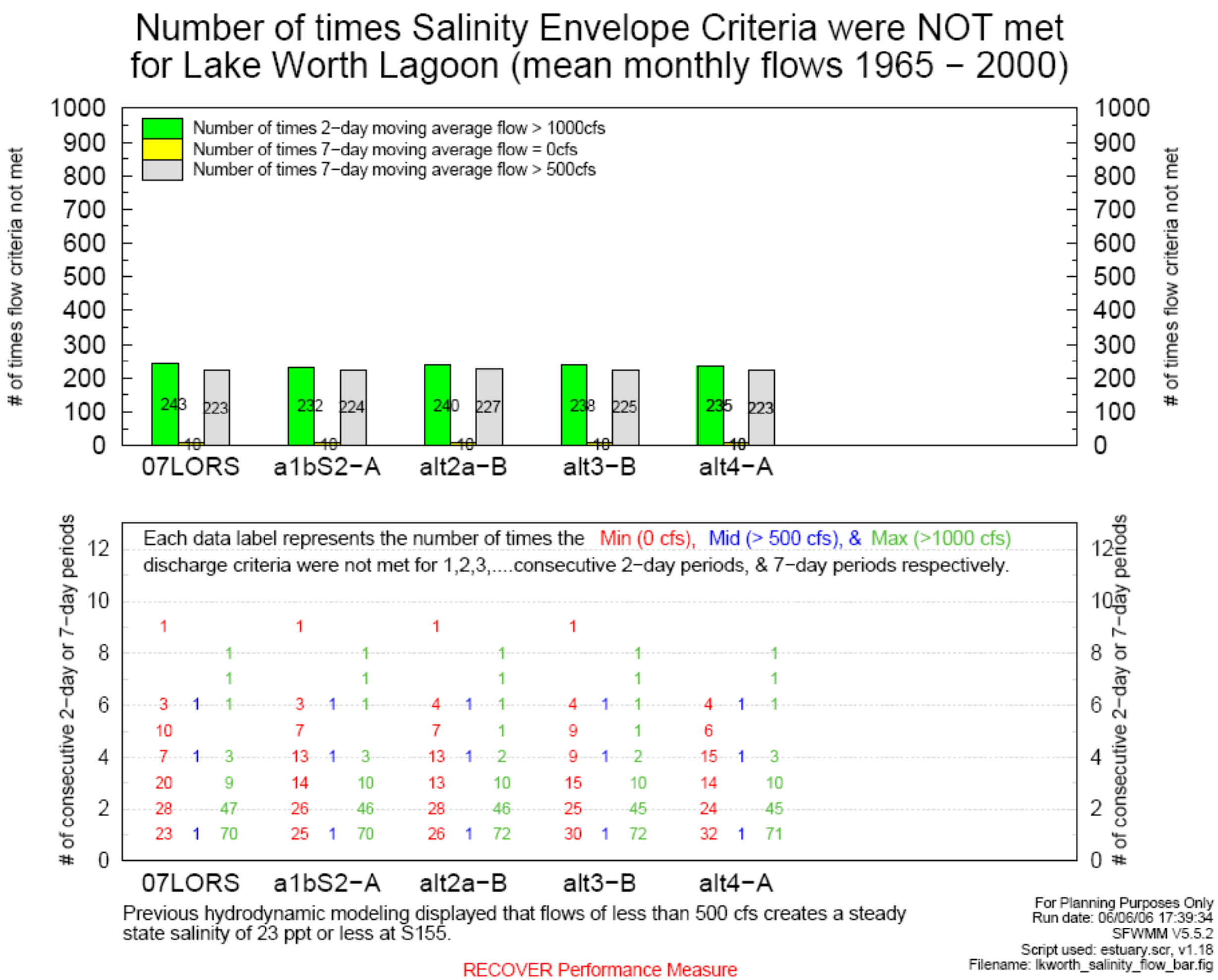


FIGURE 32: LAKE WORTH LAGOON SALINITY ENVELOPE (2)

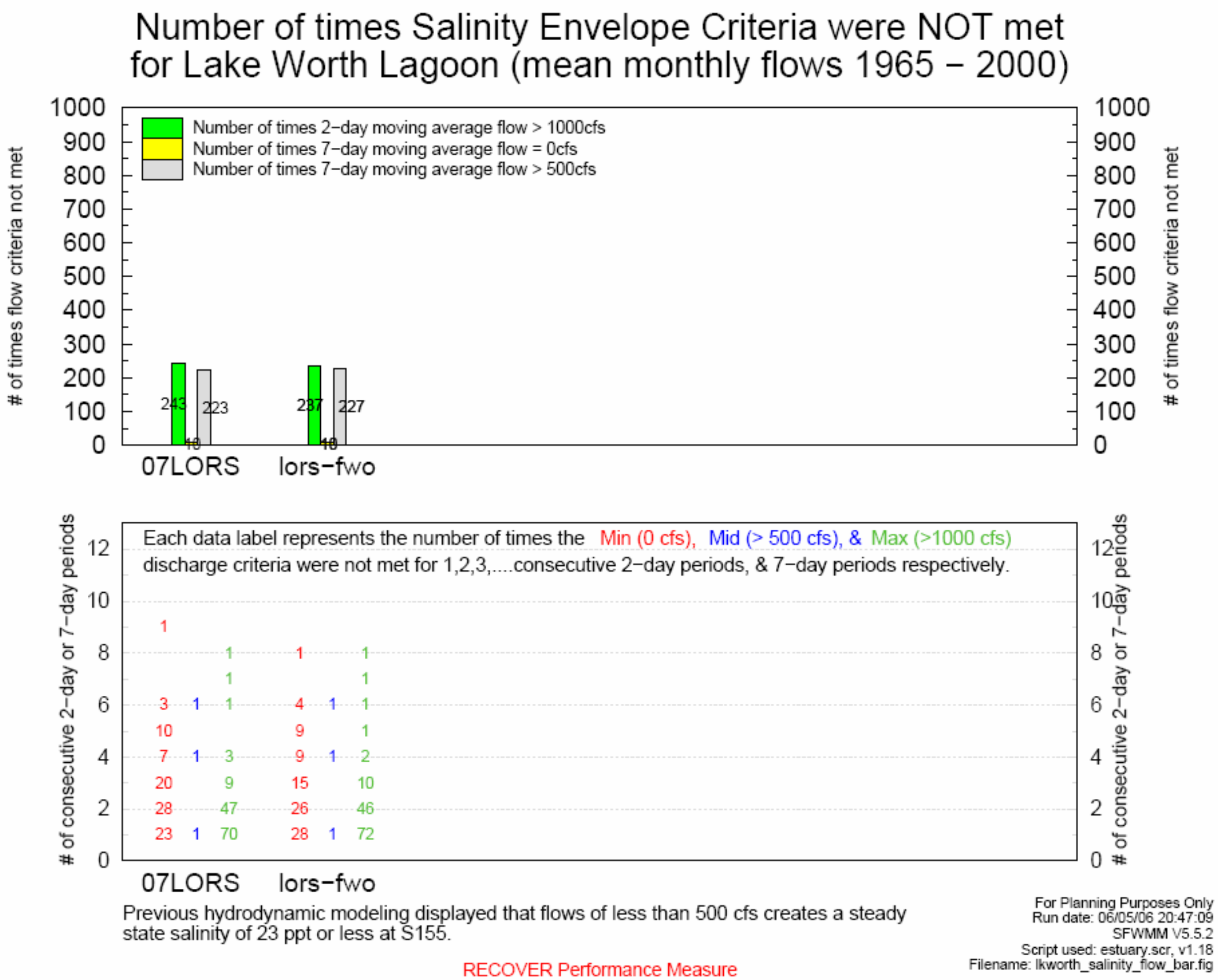


FIGURE 33: LAKE WORTH LAGOON SALINITY ENVELOPE (3)

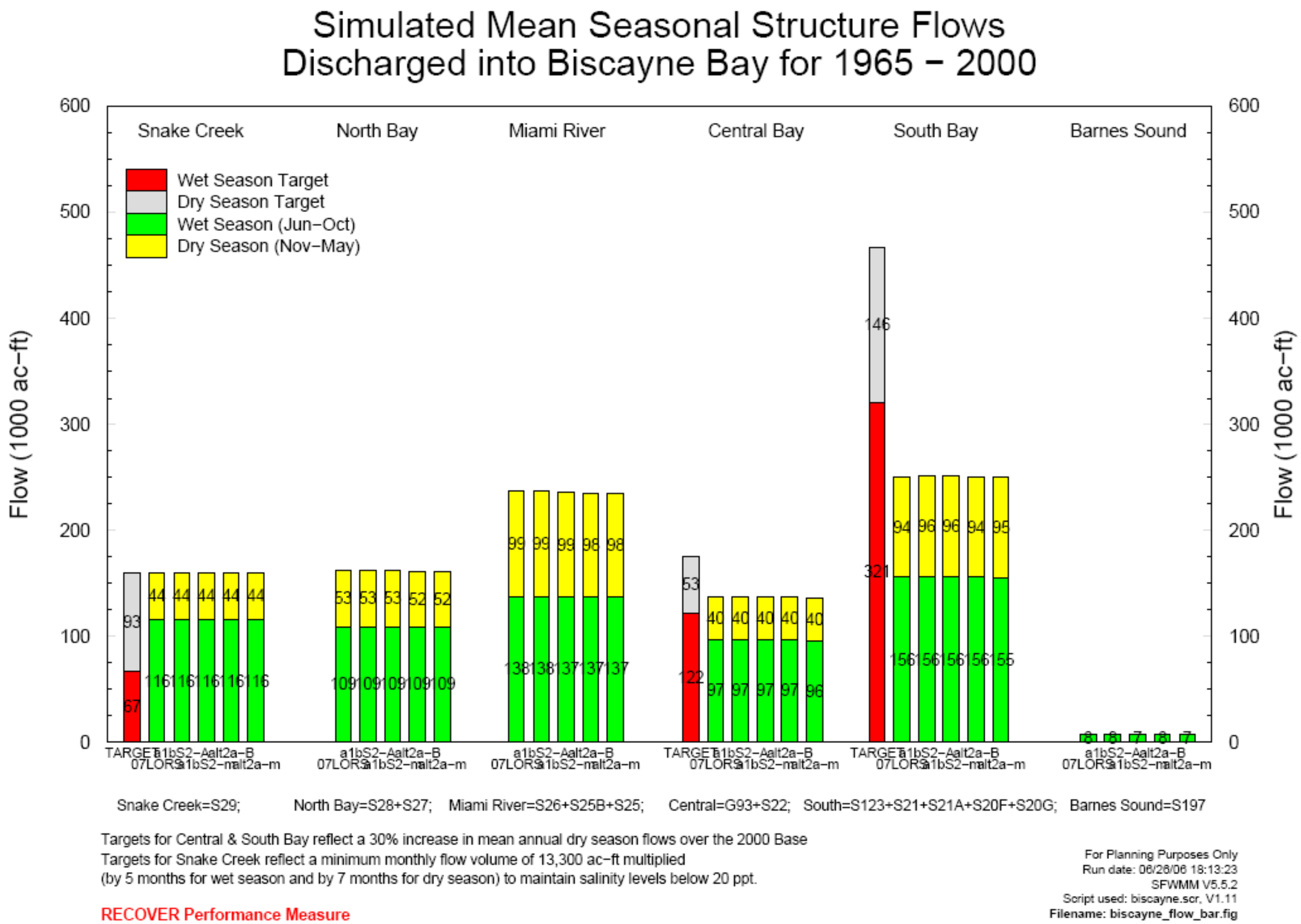


FIGURE 34: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (1)

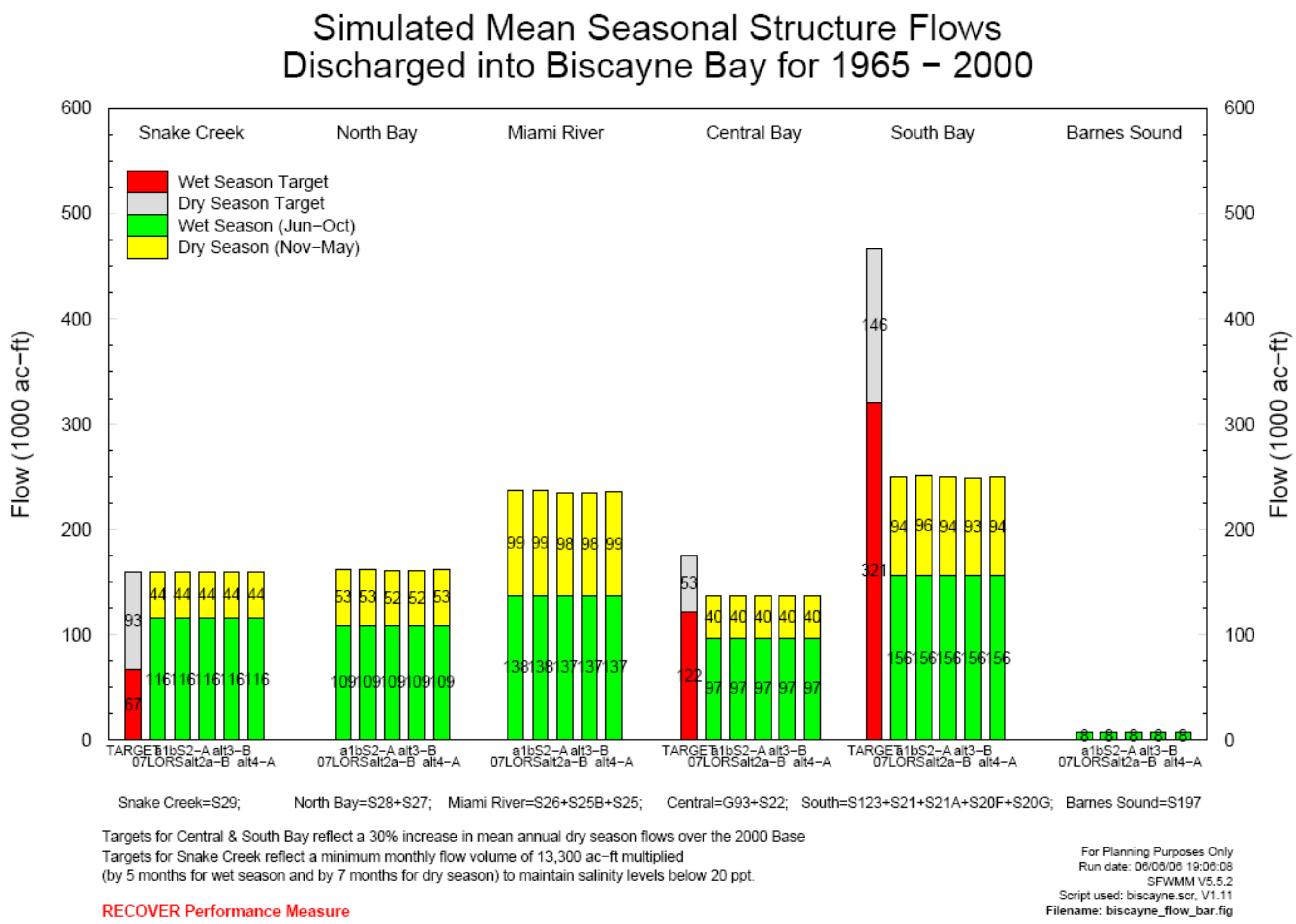


FIGURE 35: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (2)

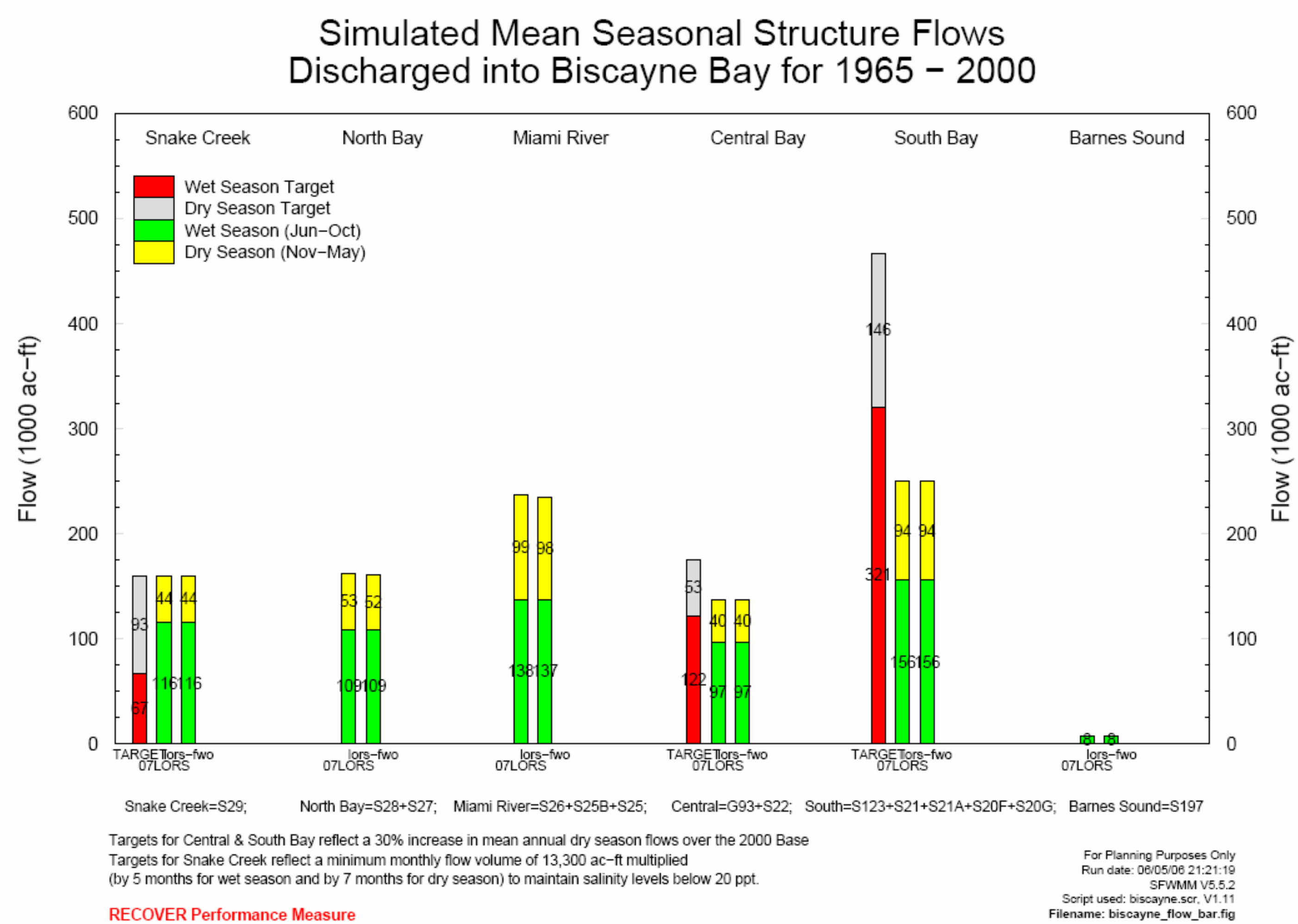


FIGURE 36: MEAN SEASONAL STRUCTURE FLOWS DISCHARGED TO BISCAYNE BAY (3)

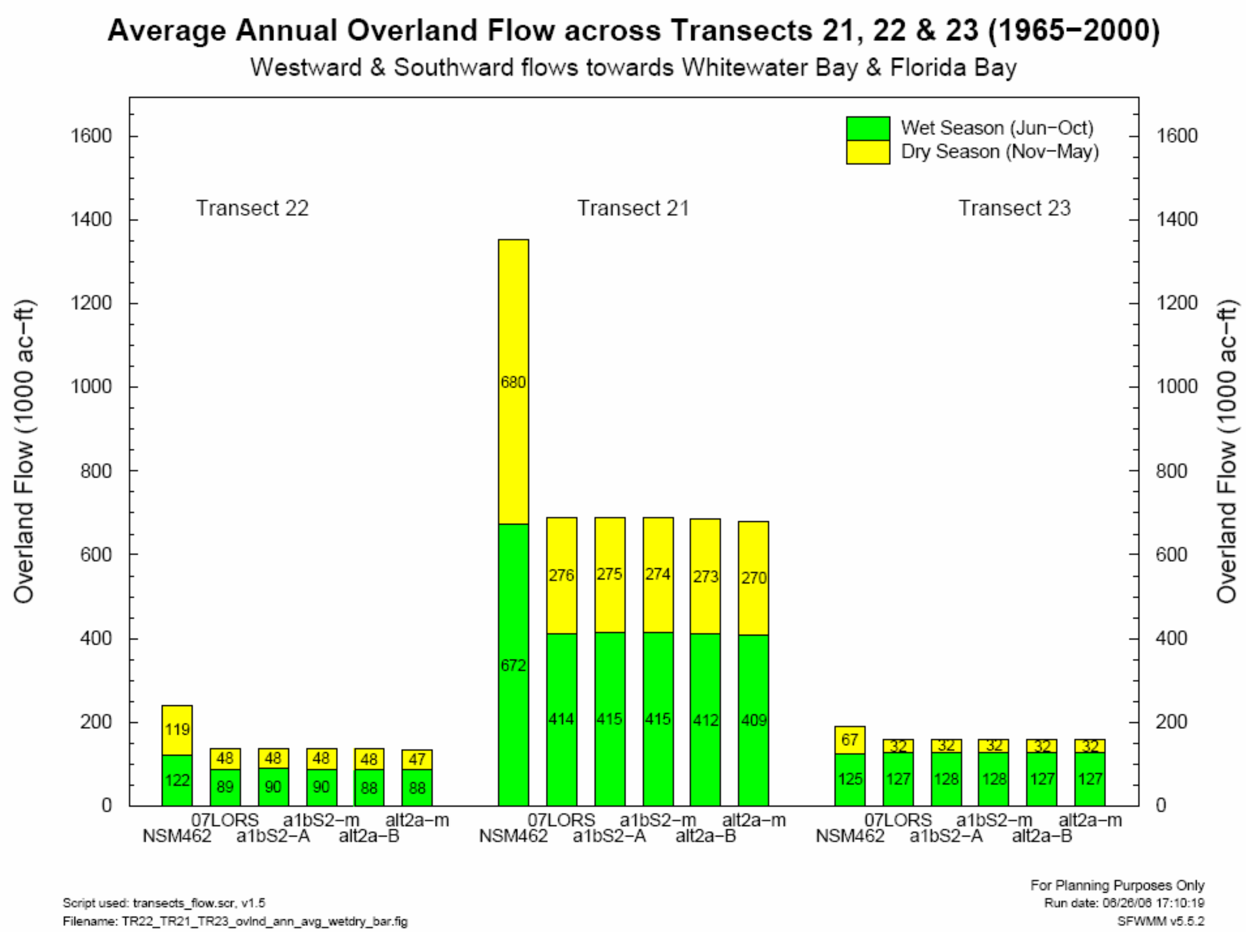


FIGURE 37: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (1)

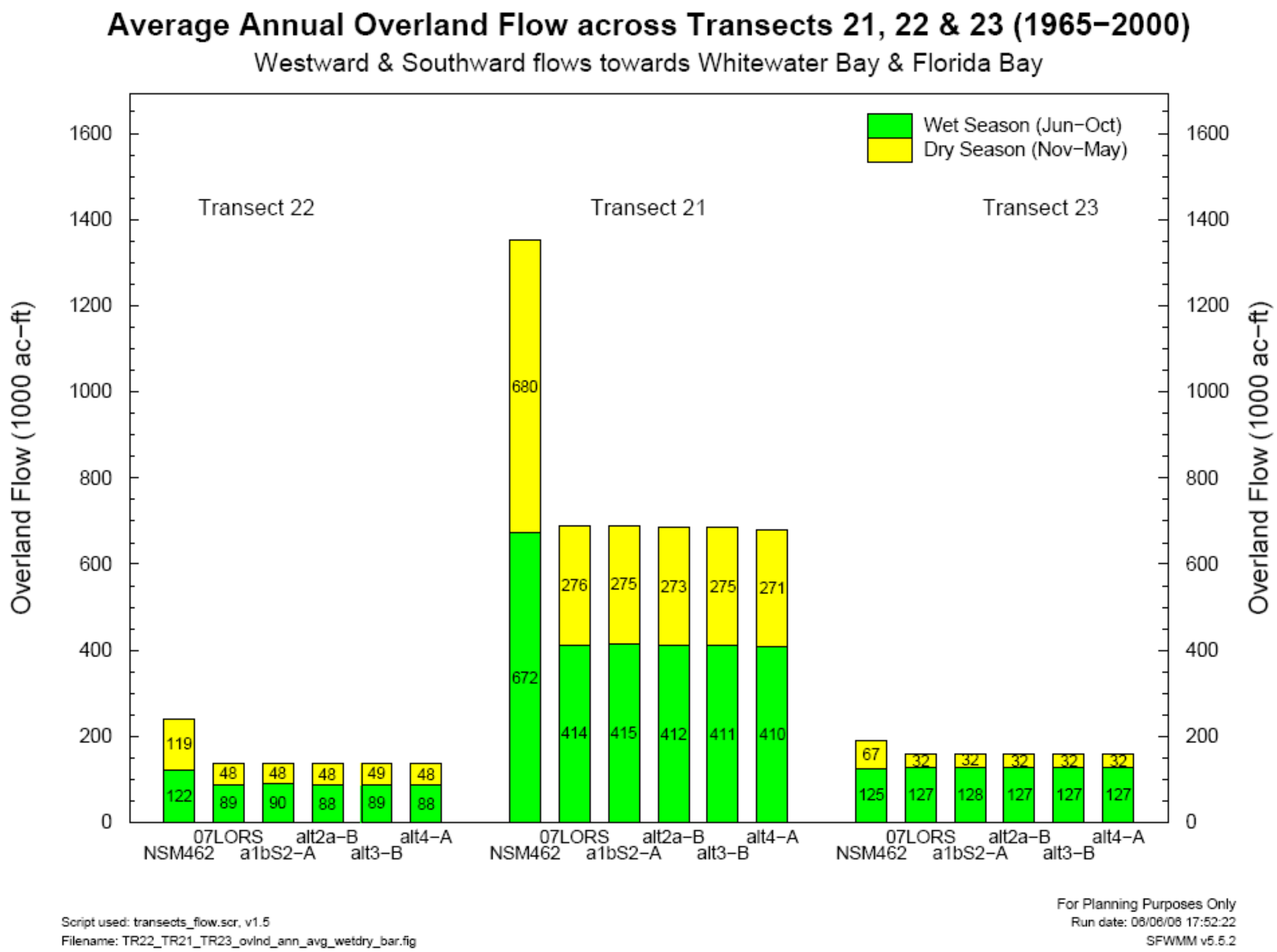


FIGURE 38: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (2)

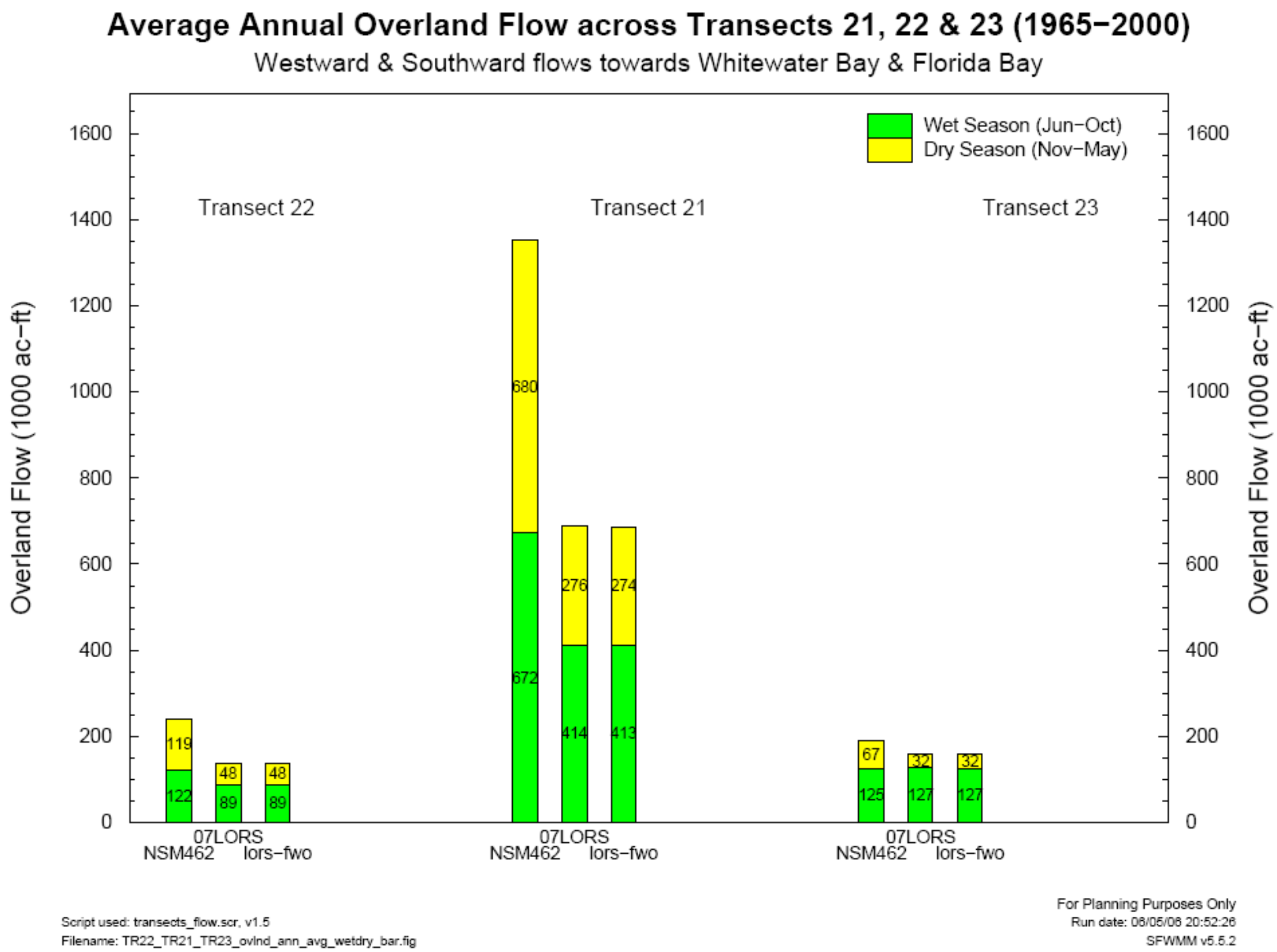


FIGURE 39: AVERAGE ANNUAL OVERLAND FLOWS TOWARDS WHITEWATER BAY AND FLORIDA BAY (3)

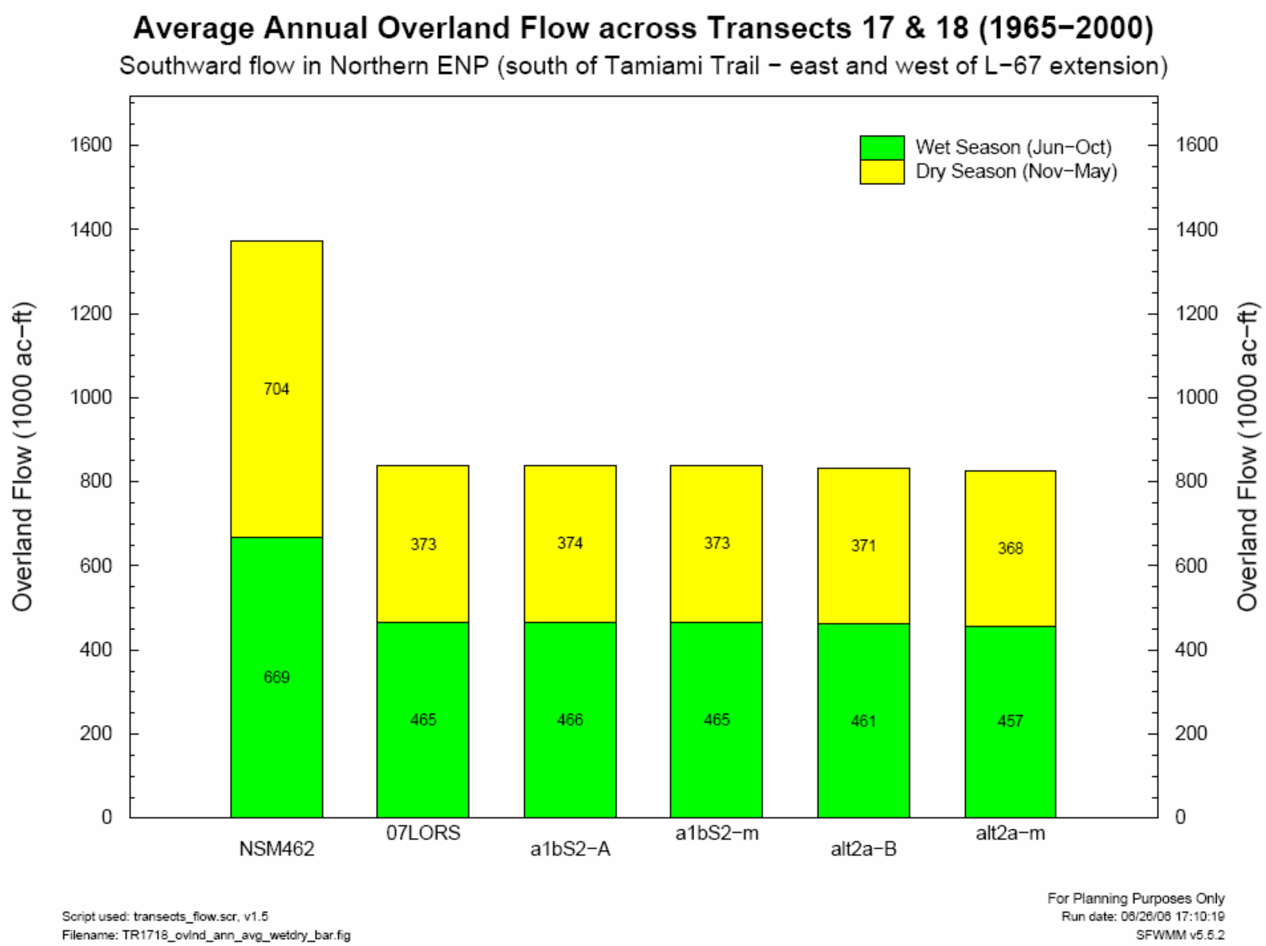


FIGURE 40: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (1)

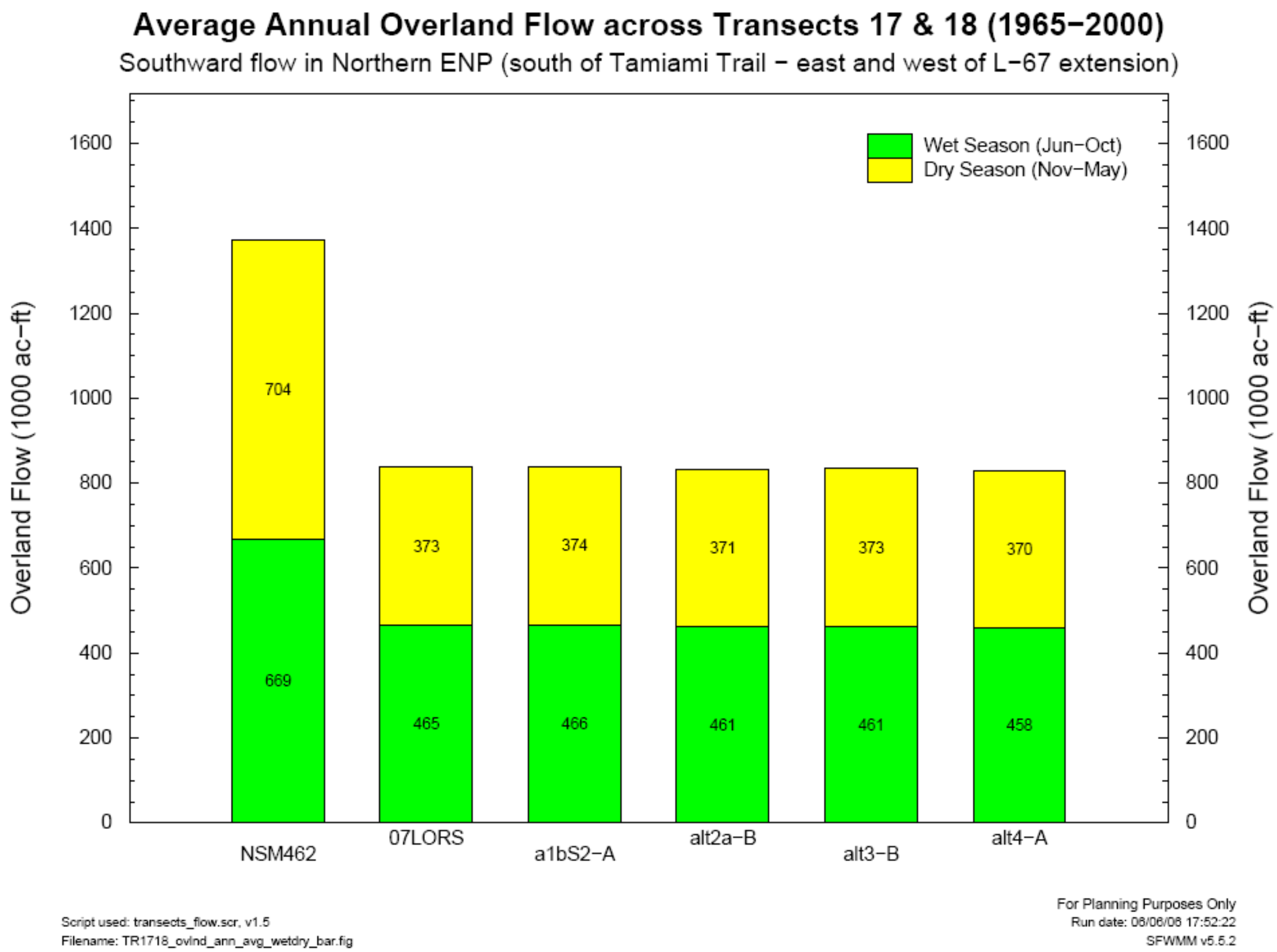


FIGURE 41: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (2)

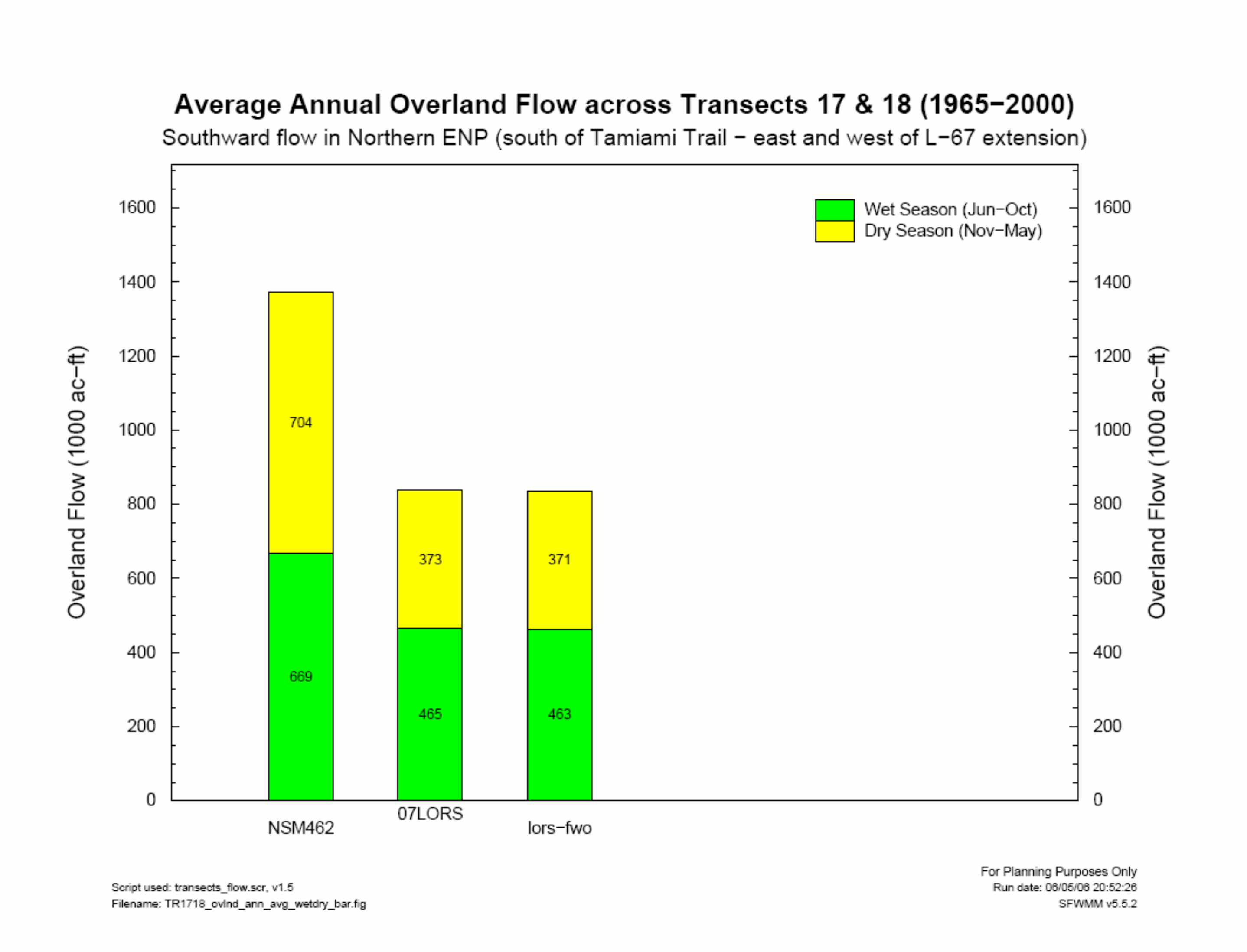


FIGURE 42: AVERAGE ANNUAL OVERLAND FLOWS TO NORTHERN ENP (3)

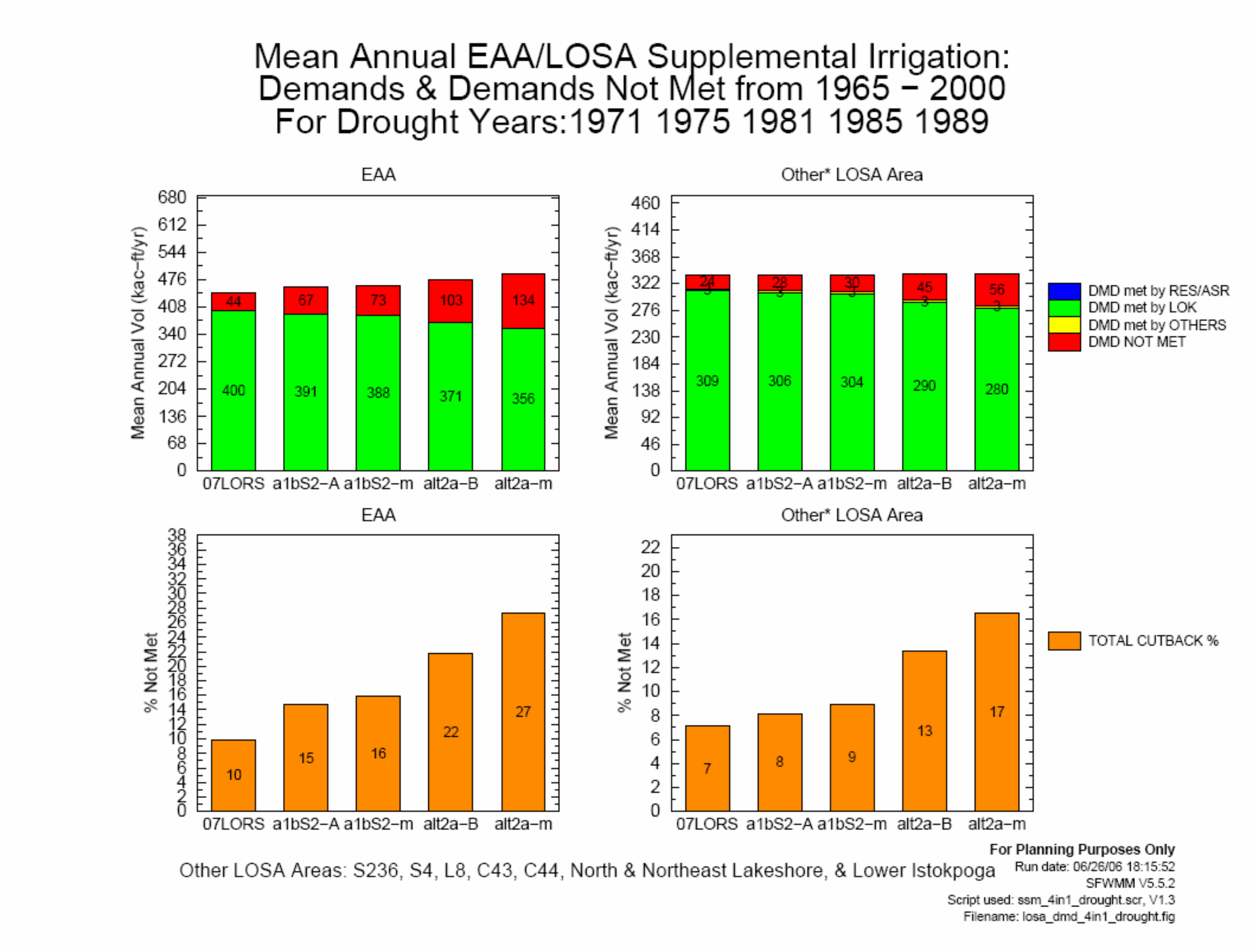


FIGURE 43: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (1)

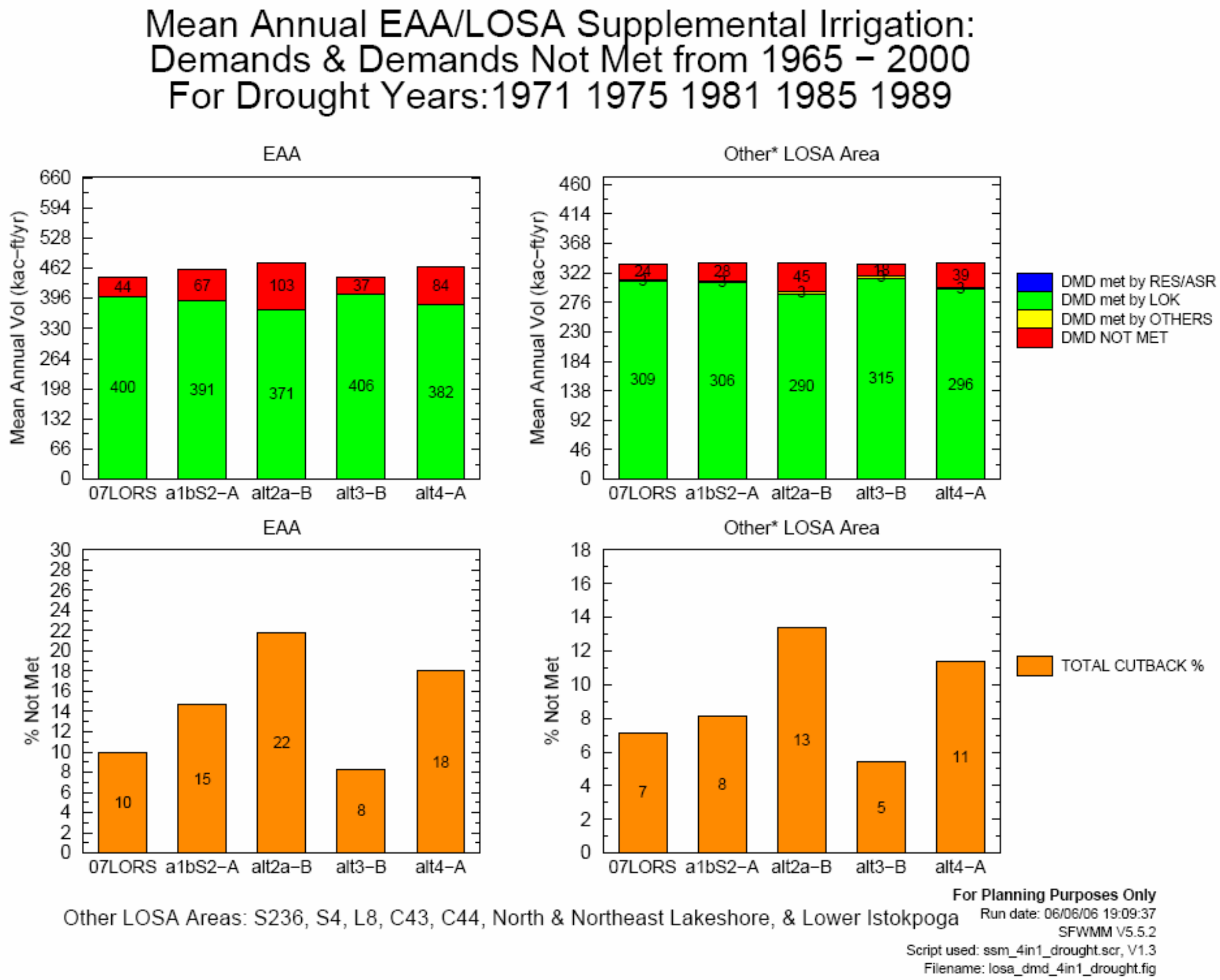


FIGURE 44: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (2)

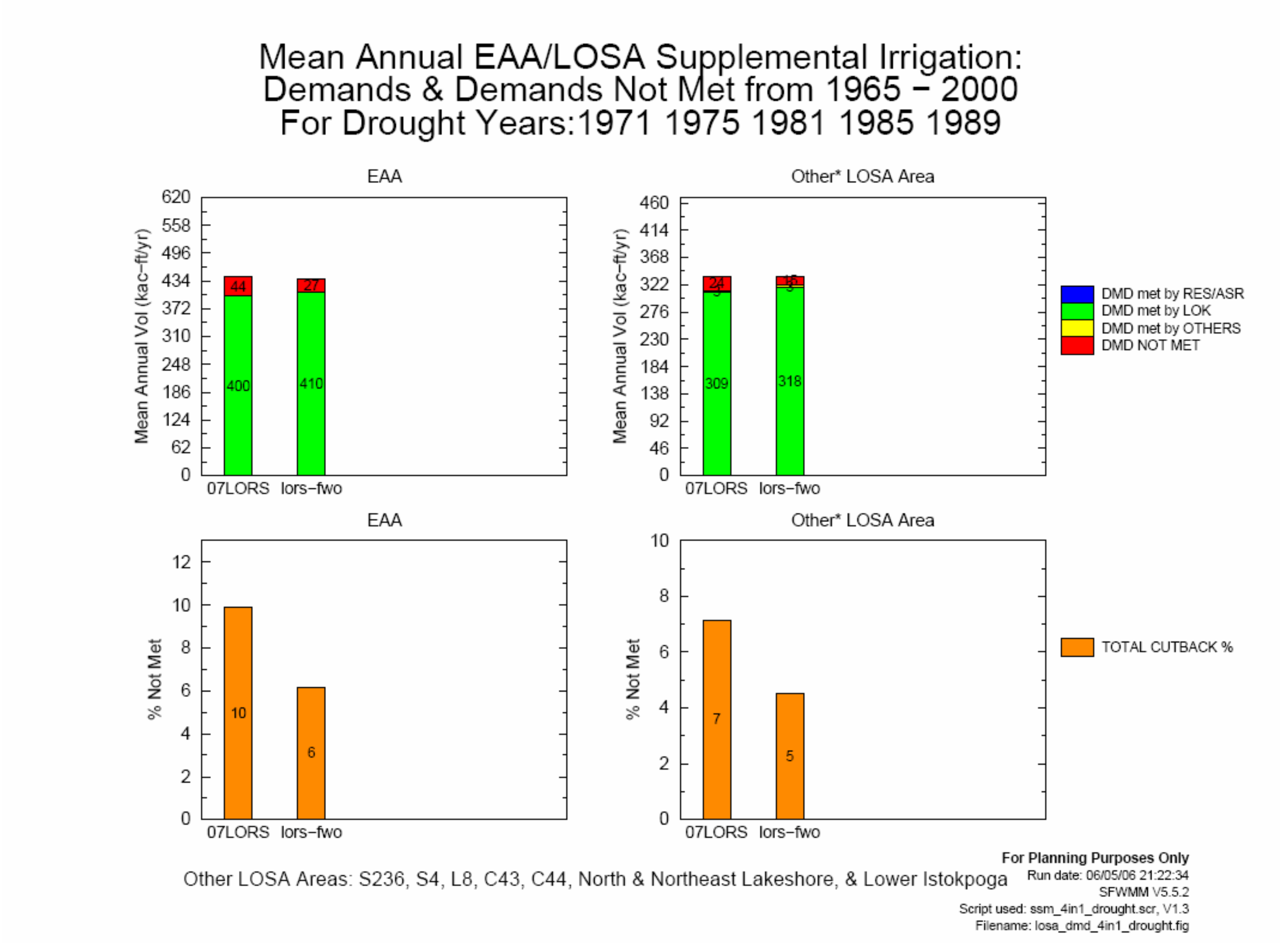


FIGURE 45: MEAN ANNUAL EAA/LOSA SUPPLEMENTAL IRRIGATION FOR DROUGHT YEARS (3)

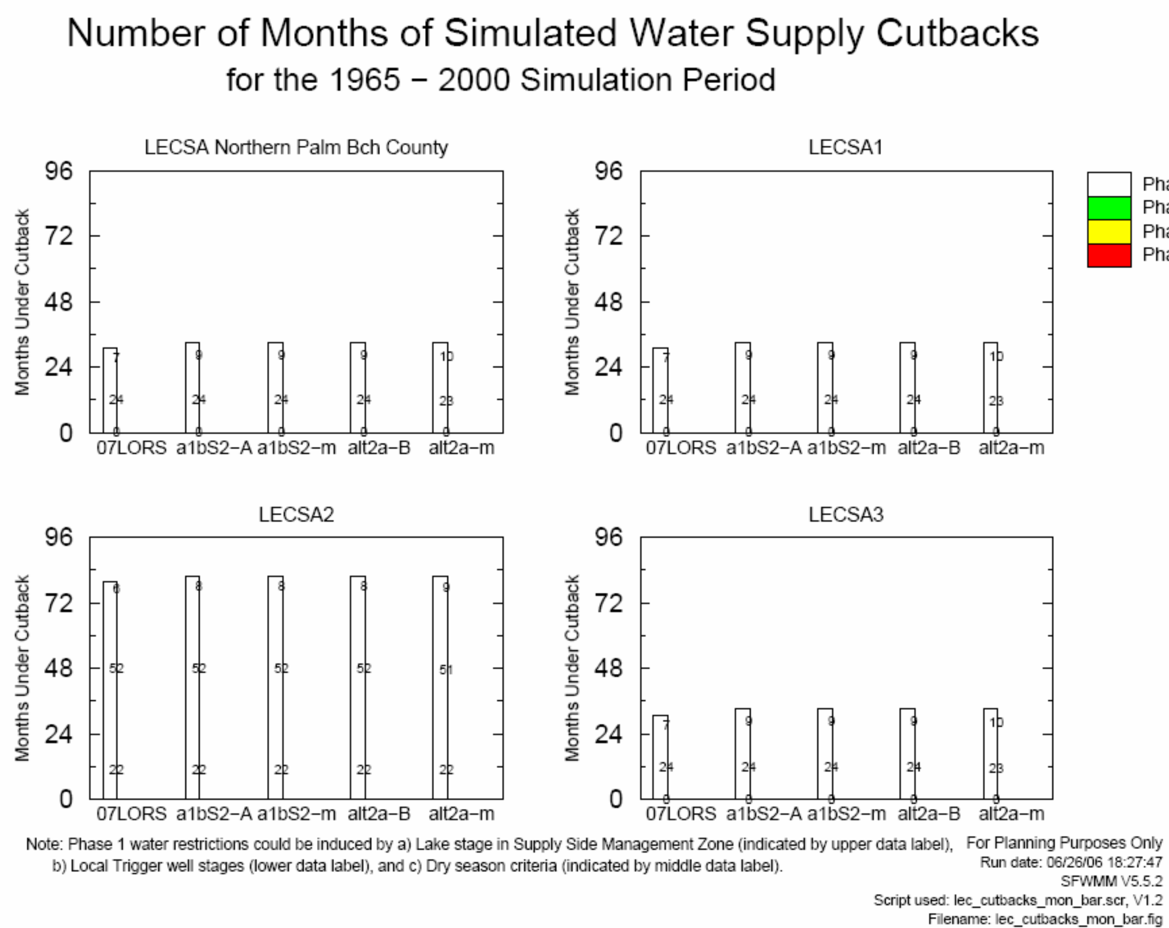


FIGURE 46: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (1)

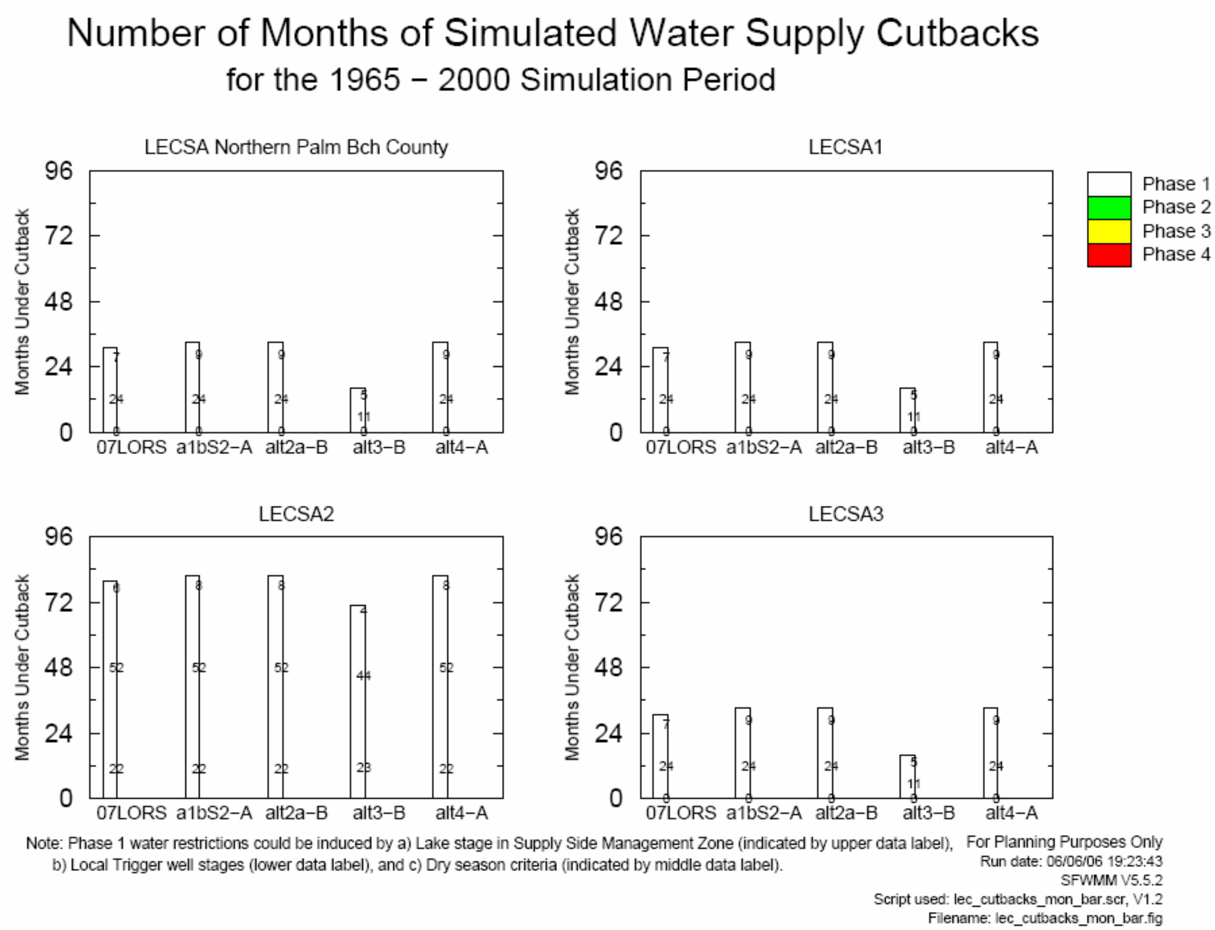


FIGURE 47: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (2)

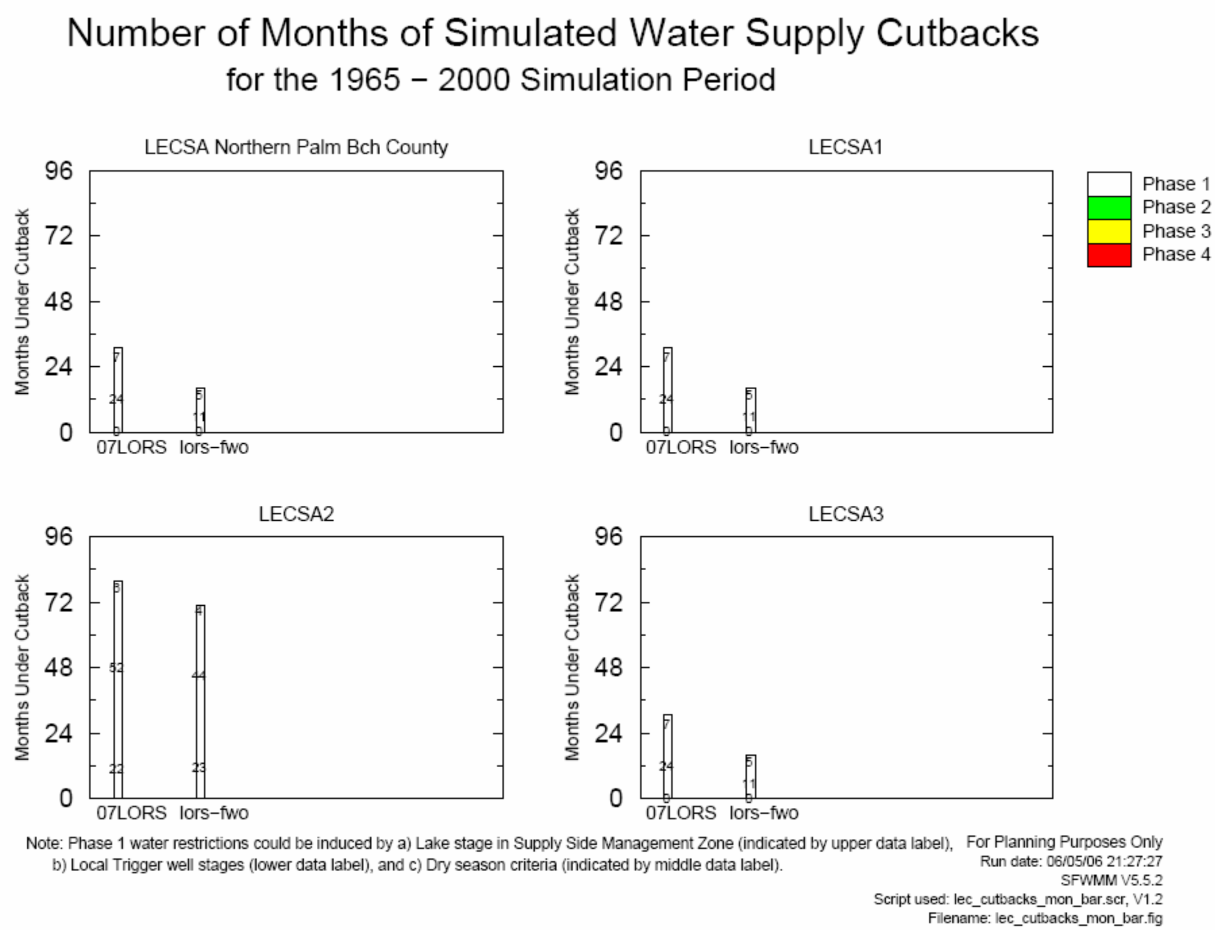


FIGURE 48: LOWER EAST COAST SIMULATED WATER SUPPLY CUTBACKS (3)

ATTACHMENT B

Summary of Assumptions used for LORSS Baseline

LORSS 2005 Base Condition
SFWMM Model Assumptions Table
(Based on Lower East Coast LEC2005 Base Condition)

Feature	Assumptions
Regional Input Data	
Climate	• The climatic period of record is from 1965 to 2000. • Rainfall estimates have been revised and updated for 1965-2000. • Revised evapotranspiration methods have been used for 1965-2000.
Topography	Updated November 2001 and September 2003 using latest available information (in NGVD 29 datum). Nov 2001 update includes: • USGS High Accuracy Elevation data from helicopter surveys collected 1999-2000 for Everglades National Park and WCA 3 south of Alligator Alley • USGS Lidar data (May 1999) for WCA 3A north of Alligator Alley • Lindahl, Browning, Ferrari & Helstrom 1999 survey for Rotenberger Wildlife Management Area. • Storm water Treatment Area surveys from 1990s • Aerometric Corp. 1986 survey of the 8-1/2 square mile area • Includes estimate of Everglades Agricultural Area subsidence • Other data as in SFWMM v3.7 • FWC survey 1992 for the Holey Land Wildlife Management Area. September 2003 update includes: • Reverting to FWC 1992 survey data for Rotenberger Wildlife Management Area. • DHI gridded data from Kimley–Horn contracted survey of EAA, 2002-2003. Regridded to 2x2 scale for EAA outside of STAs and WMAs.
Sea Level	• Sea level data from six long-term NOAA stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 2000 evaluation period.

Feature	Assumptions
Land Use	• All land use has been updated using most recent FLUCCS data (1995), modified in the Lower East Coast urban areas using 2000 aerial photography (2x2 scale).
Natural Area Land Cover (Vegetation)	Vegetation classes and their spatial distribution in the natural areas comes from the following data: • Walsh 1995 aerial photography in Everglades National Park • Rutchey 1995 classification in WCA 3B, WCA 3A north of Alligator Alley and the Miami Canal, WCA 2A & 2B • Richardson 1990 data for Loxahatchee National Wildlife Refuge • FLUCCS 1995 for Big Cypress National Preserve, Holey Land & Rotenberger Wildlife Management Areas & WCA 3A south of Alligator Alley and Miami Canal.
Lake Okeechobee Service Area	
LOSA Basins	• Lower Istopoga, S-4, North Lake Shore and Northeast Lake Shore demands and runoff based on AFSIRS modeling.
Lake Okeechobee	• Lake Okeechobee Regulation Schedule WSE according to WSE decision trees, with pulse releases in Zone D modeled as Level III pulse in upper third of the zone, Level II pulse in middle third of the zone, and Level I pulse in the lower third of the zone, when the decision tree calls for regulatory releases to the estuaries in that zone. • WSE thresholds according to the Class Limit Adjustment (CLA) for WSE: Increase the frequency of Pulse Releases in Zone D of WSE. • WSE regulatory discharges south, at times when the decision tree calls for such releases, include maximal use of discharge pathway L8 → C51 → tide, to reflect ongoing lake operations. • Lake Okeechobee Supply Side management policy for Lake Okeechobee Service Area water restriction cutbacks as per rule 40E-21 and 40E-22. • Emergency flood control back pumping to Lake Okeechobee from the Everglades Agricultural Area. • Kissimmee River inflows based on interim schedule for Kissimmee Chain of Lakes using the UKISS model.

Feature	Assumptions
	• Flood control releases south of Lake Okeechobee are constrained by WCA regulation schedules • Only STA-3/4 would be used to treat LOK regulatory releases to the south
Caloosahatchee River Basin and S-4 Basins	• Caloosahatchee River Basin irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage. • Public water supply daily intake from the river is included in the analysis.
St. Lucie Canal Basin	• St. Lucie Canal Basin demands estimated using the AFSIRS method based on existing planted acreage. • Basin demands include the Florida Power & Light reservoir at Indiantown.
Seminole Brighton Reservation	• Brighton reservation demands were estimated using AFSIRS method based on existing planted acreage in a manner consistent with that applied to other basins not in the distributed mesh of the SFWMM. • The 2 in 10 demand set forth in the Seminole Compact Work plan equals 2,262 MGM (million gallons/month). AFSIRS modeled 2 in 10 demands equaled 2,383 MGM. • While estimated demands, and therefore deliveries, for every month of simulation do not equate to monthly entitlement quantities as per Table 7, Agreement 41-21 (Nov. 1992), tribal rights to these quantities are preserved. • Supply-side Management applies to this agreement.
Seminole Big Cypress Reservation	• Big Cypress Reservation irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage in a manner consistent with that applied to other basins not in the distributed mesh of the SFWMM. • The 2 in 10 demand set forth in the Seminole Compact Work Plan equals 2,606 MGM. AFSIRS modeled 2 in 10 demands equaled 2,659 MGM. • While estimated demands, and therefore deliveries, for every month of simulation do not equate to monthly entitlement quantities as per the District’s Final Order and Tribe’s Resolution establishing the Big Cypress Reservation entitlement, tribal rights to these quantities are preserved.

Feature	Assumptions
	• Supply-side Management applies to this agreement
Seminole Hollywood Reservation	• Hollywood Reservation demands are set forth under VI. C of the Tribal Rights Compact. • Tribal sources of water supply include various bulk sale agreements with municipal service suppliers.
Everglades Agricultural Area	• Everglades Agricultural Area irrigation demands are simulated using climatic data for the 36 year period of record and a soil moisture accounting algorithm, with parameters calibrated to match historical regional supplemental deliveries from Lake Okeechobee. • SFWMM EAA runoff and irrigation demand response to rainfall was calibrated for 1984-95 and verified for 1979-1983/1996-2000. No runoff reduction adjustment was necessary to account for Best Management Practices (BMPs). • EAA cells in the Miami Canal Basin between STA5 and STA6 are not production cells (shrub Land Use). Then, no irrigation demands are required in this area. Runoff from this area is part of the Miami Canal Basin.
Everglades Construction Project Stormwater Treatment Areas	• Stormwater Treatment Area 2 is connected to the regional system and operational. STA-2 all three cells operational (6,430 acres on line) • STA 1E is built and in place, but not operational. • STA-1W is partially operational with approximately 5,371 acres on line • STA-5 is partially operational with approximately 2,890 acres on line • STA-6 Section 1 operational with 897 acres on line • STA-3/4 is partially operational with approximately 11,000 acres on line • Operation of Storm water Treatment Areas assumes maintenance of a 6" minimum depth.
Holey Land Wildlife WMA	• As per Memorandum of Agreement between the FWC and the District.
Rotenberger	• Interim Operational Schedule as defined in the Operation Plan for Rotenberger, 2001.

Feature	Assumptions
Wildlife WMA	
Water Conservation Areas	
Water Conservation Area 1 (ARM Loxahatchee National Wildlife Refuge)	• Current C&SF Regulation Schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 14 ft. The bottom floor of the schedule (Zone C) is the area below 14 ft. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Water Conservation Area 2 A&B	• Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels in WCA 2A are less than minimum operating criteria of 10.5 feet. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Water Conservation Area 3 A&B	• Current C&SF regulation schedule for WCA 3A, as per Water Control Plan –Interim Operational Plan (IOP) for protection of the Cape Sable seaside sparrow-C&SF Project for Flood Control and other Purposes, 2002. • Includes regulatory releases to tide through LEC canals. Documented in Water Control Plan, 2002. • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 7.5 feet in WCA 3A. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.
Lower East Coast Service Areas	
Public Water Supply and Irrigation	• Public water supply wellfield pumpages and locations are based on actual pumpage data for calendar year 2004. • Irrigation demands are based upon existing land use (updated through 2000) and calculated using AFSIRS, reduced to account for landscape and golf course areas irrigated using reuse water and landscape areas irrigated using public water supply.

Feature	Assumptions
Other Natural Areas	• For the Northwest Fork of the Loxahatchee River, the District operates the G-92 structure and associated structures to provide approximately 50 cfs over Lainhart Dam to the Northwest Fork, when sufficient water is available in C-18 Canal. • Flows to Pond Apple Slough through S-13A are adjusted in the model to approximate measured flows at the structure. • Flows to Biscayne Bay are simulated through Snake Creek, North Bay, the Miami River, Central Bay and South Bay.
Coastal Basin Canal Facilities and Operations	• C&SF system and operating rules in effect in 2005. • Includes operations to meet control elevations in the primary coastal canals for the prevention of saltwater intrusion. • Includes existing secondary drainage/water supply system. • C-4 Flood Mitigation Project • C-11 Water Quality Treatment Critical Project (S-381 and S-9A) • Releases from WCA 3A to ENP and the South Dade Conveyance System (SDCS) will follow the Interim Operational Plan (IOP): o Decreased S-12 flood control discharges and increased flood control discharges to SDCS o Structures S-343A, S-343B, S-344 and S-12A are closed Nov. 1 to July 15 o Structure S-12B is closed Jan. 1 to July 15. o Structure S-12C is closed Feb. 1 to July 15. o South Dade Conveyance System operations will follow IOP for protection of the Cape Sable seaside sparrow
Western Basins and Big Cypress National Preserve	
Western Basins	• Estimated and updated historical inflows from western basins at two locations: G-136 and G-406. The G-406 location represents potential inflow from the C-139 Basin into STA 5. Data for the period 1978-2000 is the same as the data used for the C-139 Basin Rule development.

Feature	Assumptions
Big Cypress National Preserve	• Simulated demands in excess of historical demands are partially supply by basin flows. Any remaining excess water is directed to S-190. • Tamiami Trail culverts are not modeled in SFWMM due to the coarse (2x2 mile) model resolution
Everglades National Park and Florida Bay	
Everglades National Park	• Water deliveries to Everglades National Park are based upon the Interim Operational Plan (IOP). • When stages in WCA 3A fall in Zone E1 of the regulation schedule and the stage at G-3273 is below the critical threshold, S-333 flows are directed to the Park, a fraction of which is released through S334. This simulation is consistent with IOP ALT7RP2.
Region-wide Water Management and Related Operations	
Water Shortage Rules	• The existing condition reflects the existing water shortage policies in 2005 as reflected in SFWMD Chapters 40E-21 and 40E-22, FAC